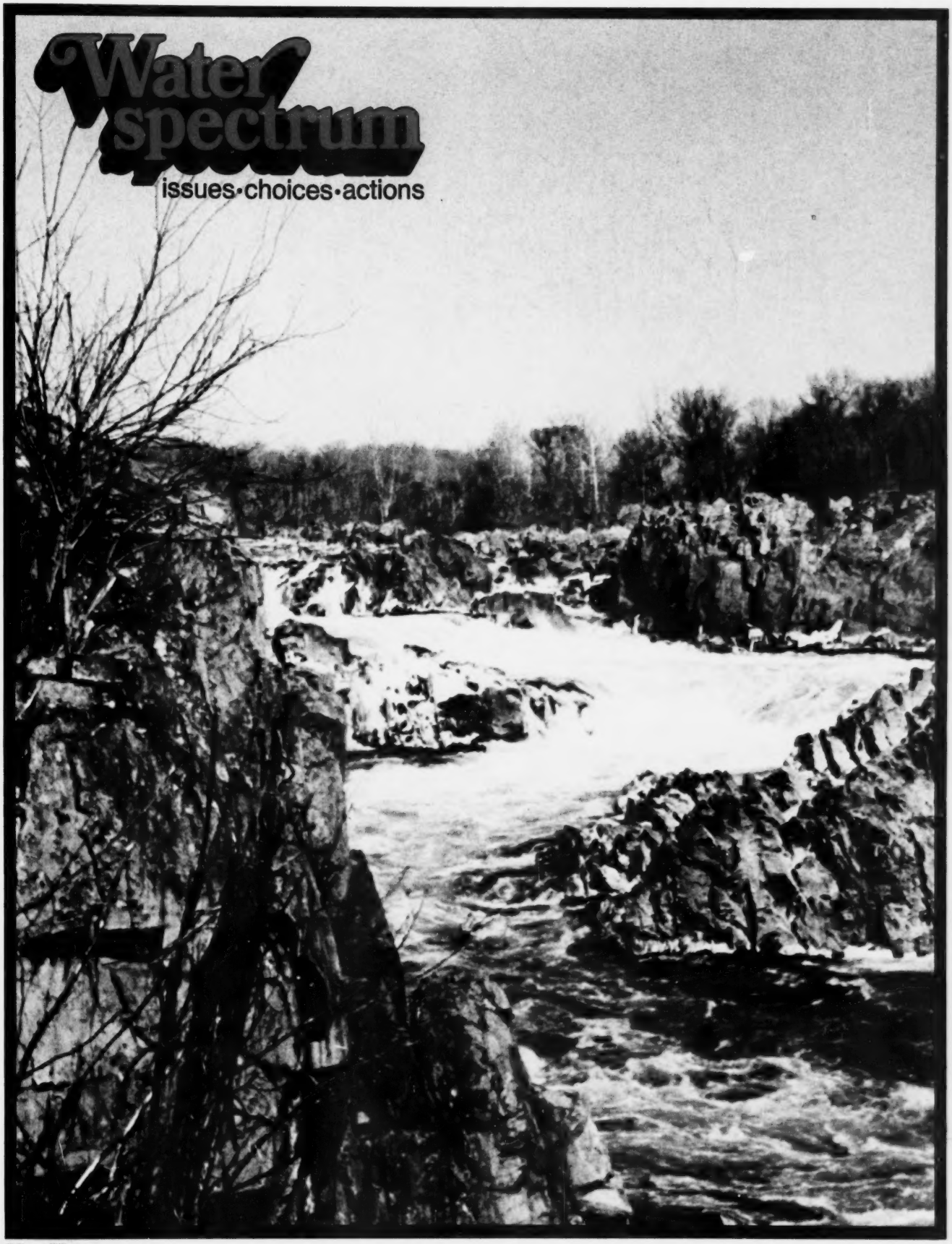
Water spectrum

issues·choices·actions



DEPARTMENT OF THE ARMY, CORPS OF ENGINEERS

Vol. 5, No. 4, 1973

Water Spectrum
issues · choices · actions

Vol. 5, No. 4, 1973
Published quarterly

Secretary of the Army
Howard H. Callaway

Chief of Engineers
Lt. Gen. W. C. Gribble, Jr.

Director of Civil Works
Maj. Gen. J.W. Morris

EDITOR
Edwin E. Chandler

ASSISTANT EDITOR
Seymour Reitman

1 **Nature's Dynamics: An Elevated Perspective**
by Lt. Scott C. Sollers

9 **Myths: Cornerstones for Counterpositions**
by Harold M. Stults

16 **Overland Flow**
by P. G. Hunt

22 **Two Objectives and Four Accounts**
by Warren D. Fairchild

28 **Three-Year Evolution**
by C. Grant Ash

36 **Wave Breaking: A Self-Help Tactic**
by Ronald Buddecke and Norman Arno

43 **Events, Deeds & Deliberations**

Comments on topics in this publication are invited. Send to:
Editor, Water Spectrum
Office, Chief of Engineers
Department of the Army
Washington, D.C. 20314

Letters to authors c/o Editor will be forwarded.

Use of funds for printing this quarterly publication was approved by the Director of the Office of Management and Budget on January 6, 1972, with approval to publish through December 31, 1976.

A major purpose of this publication is to serve as a written forum for the open discussion of issues and choices in resolving water resource problems. Views and conclusions expressed or implied do not necessarily reflect the position of the Corps of Engineers.

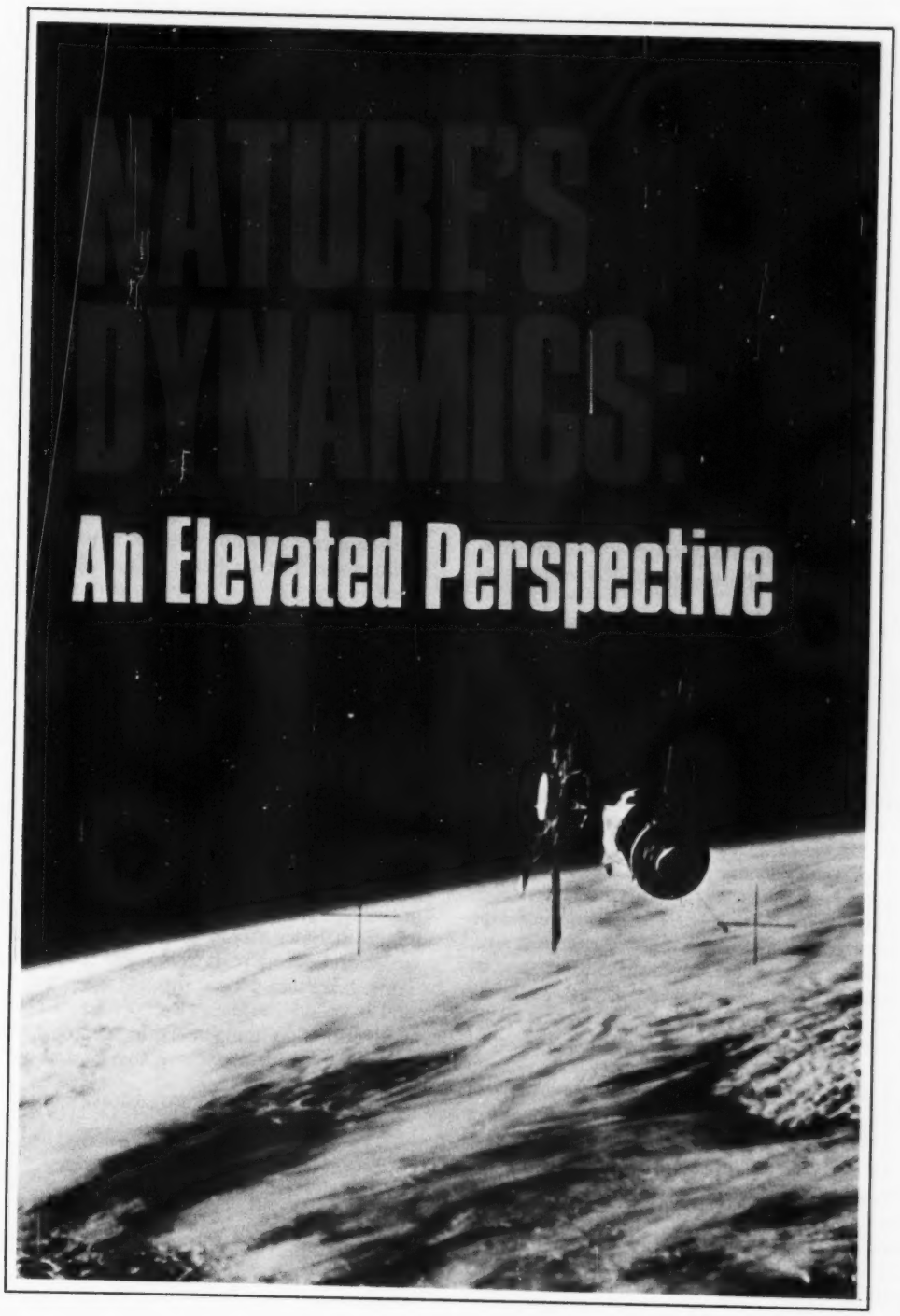
Subscription rate is $4.50 per year; $1.25 additional for foreign mailing. Price of a single copy is $1.25. Order directly from Superintendent of Documents, Government Printing Office, Washington, D.C. 20402

This issue developed by Policy and Analysis Division, Directorate of Civil Works.

Address changes: Please attach old address label to request for changes.

COVER: Does this stream, as one supply for a metropolitan population, represent scarcity? See page 9.

PHOTO CREDITS:
Front and back cover pictures:
Charles E. Holden,
Washington, D.C.


NATURE'S
DYNAMICS:
An Elevated Perspective

by Lt. Scott C. Sollers

Remote sensing from an orbiting satellite defines the dynamics of nature in somewhat the same fashion that time sequence photography captures the slow unfolding of a flower petal or the gradual swell of a germinating seed. Remote sensing of the earth's terrain and water is much broader in scope, however, and it also furnishes information and data on features of the natural environment at an unprecedented rate. Furthermore, development of the technology arrives at a crucial period in the management of the Nation's water and related resources. This period is characterized by increased public demands that any potentially adverse effects of development or intensive management be defined as fully as possible.

One cannot properly predict these effects, though, without a prior assessment of existing conditions. It would be unreasonable and impractical to inventory all aspects of the environment. A water resources project will impact more on certain critical features than others. The key to the planning process is, therefore, to identify on a preproject basis those critical or "evaluative" factors that will eventually be affected. It is in this effort that the new technology—remote sensing—will predictably have significant impact.

Remote sensing is becoming a more frequently used term among laymen, but it is still often misunderstood. Stated simply, *remote sensing is the acquisition of data using a distant platform.* For example, the human eye, the original remote sensor, perceives differences in radiation being reflected from objects and transmits these perceptions in the form of electronic signals to the brain, where they are identified and classed according to memory.

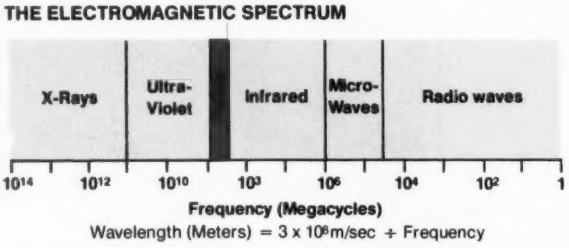
The eye's ability to discern radiation is compromised, however, because it is restricted to a rather narrow range of the electromagnetic spectrum (figure 1). This spectrum consists of the X-ray, ultra-violet, visible, reflected and emitted infrared, microwave and radio bands. The eye, of course, is sensitive only to the visible portion of the spectrum. Now that technology has produced more sophisticated sensors that can capture and record radiation reflected and emitted in other than just the visible sector, our effective vision is expanded to include those hitherto invisible regions.

Lieutenant Sollers is currently assigned to the Office, Chief of Engineers as a remote sensing specialist and staff ecologist.

Remote sensors not only record more information about objects than the eye, they also have several other capabilities. The two Military Directorates of the Corps have been active for many years in the development and evaluation of these capabilities. Then, last year, the Civil Works Directorate decided to investigate the potential applications of this technology and, with NASA technical assistance and funding, initiated a program devoted to the transfer of remote sensing technology from theoretical research to applications development. This program is attempting to apply the capabilities of remote sensor systems to problems faced in the performance of the Civil Works mission. Remote sensing can facilitate the accomplishment of this mission by providing near-real time data with synoptic coverage which allows for a greater precision in gross evaluations of large ecosystems and a convenient method to monitor change.

At present this program consists of 30 different projects that consider the impact of a variety of activities on several of our natural resources. Figure 2 is a matrix that illustrates the breadth and scope of this program. Since the Civil Works Directorate of the Corps is basically a water resource agency, the emphasis of this research program is obviously on water resources. In figure 2 *land resources* include, but are not limited to, construction materials, geologic features and flora and fauna; *ground water* includes freely moving and trapped subsurface water and permafrost; *fresh water* includes rivers, reservoirs, lakes and ponds; *brackish water* refers to estuaries and bays, and *saline water* consists of coastal regions.

Identified in the matrix cells are sensor platforms being employed to perform that particular research ef-



1. The human eye is receptive to only a very small portion of the electromagnetic spectrum. Remote sensors have enabled us to "see" into invisible regions.

ACTIVITIES \ RESOURCES	LAND	GROUND WATER	FRESH WATER	BRACKISH WATER	SALINE WATER
INVENTORIES	Satellite Aircraft	Satellite	Aircraft	Satellite	Aircraft
ENVIRONMENTAL IMPACT ASSESSMENT	Aircraft		Satellite		
POLLUTION MONITORING			Aircraft		
WATER CIRCULATION AND SEDIMENT TRANSPORT MAPPING			Aircraft	Satellite	Satellite
FLOOD CONTROL			Satellite Aircraft		
ENGINEERING	Aircraft	Aircraft			
MODEL VERIFICATION					Aircraft

2. Corps of Engineers remote sensing research and applications program.

fort. These platforms include both aircraft and satellite sensor systems. A vacant cell means the impact of that activity on that natural resource is not being investigated. It should be emphasized that this matrix represents the ongoing Corps civil works program. As this program expands the remaining topics may also be addressed, along with others, as the need arises.

A discussion of several projects *and the remote sensing techniques employed therein* will illustrate the impact of remote sensing on the planning process.

Recently the Corps broke ground for construction of the Tennessee-Tombigbee Canal. When completed, this canal will provide a navigable route between the Tennessee and Tombigbee Rivers. Because these two rivers vary in silt and pollution content, elevation and supportive vegetation, it was necessary to assess not only the impact of the canal on the affected environment but the effect of joining the two fluvial systems.

The planning for this project was facilitated by a study conducted by Frank Miller of Mississippi State University under contract to the Corps. Miller employed NASA aircraft imagery in his study of the proposed canal route. The major emphasis was on the impact of channelization, impoundments, spoil disposal and river widening on the environments—but also considered were the indirect effects of raising or lowering water tables, constraining river courses, diverting or blocking the existing surface drainage ways and relatively small fluctuations in the water levels of existing impounded areas. The results of this study have been extremely helpful to Corps planners.

Miller's approach was to study seasonal aircraft coverage of the test area for physiographic regions, vegetation types and wildlife habitats (figures 3 and 4). Once environmental baseline conditions were known, the task of predicting the effect of these activities on the various ecosystems could begin.[1]

Remote sensed data were also used in the analysis of the route of the recently approved Alaskan pipeline. Aircraft radar imagery of the route was obtained in the fall of 1972 and studied for geologic information. (Figure 5 traces the pipeline route in relation to the Denali Fault.)

Use of radar imagery in surveying the pipeline route has the advantage of being virtually unaffected by cloud conditions or sun angle. Flight time, therefore, depended mostly on convenience for the crew rather than weather or time of day. Radar is an "active" system; that is, a signal is sent from the sensor and the varying time this signal takes to return from each ground feature to the aircraft is recorded and used to produce an image that accurately reflects the topography of the site. This detailed topographic information can then be used to infer geologic features.

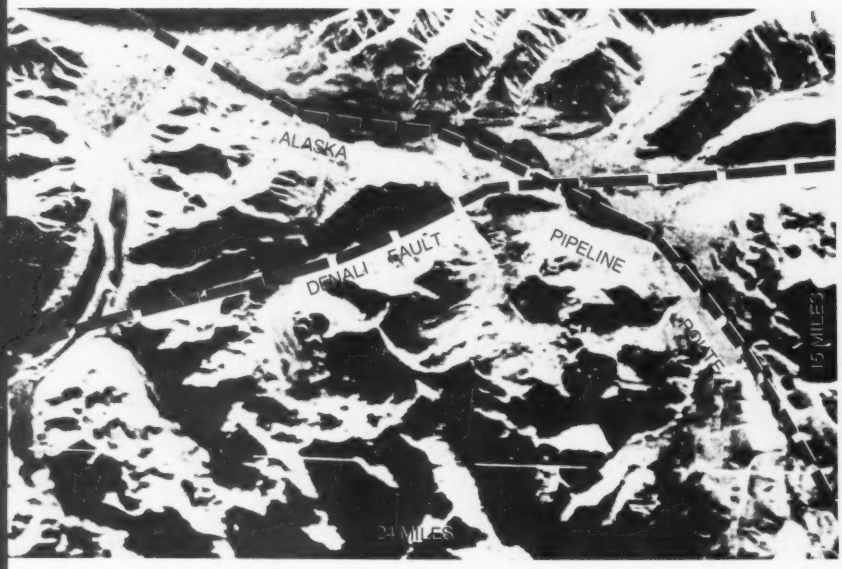
Any critical fault zone may be identified and subsequently field checked for activity in this fashion. In this instance, the results of the analysis will be helpful in determining the exact pipeline location and in defining design criteria for the structure.

With the launching of the Earth Resources Technology Satellite (ERTS) in July 1972, NASA entered into an unprecedented expansion of the remote sensing technique by elevating its operating platform to a 492 nautical mile circular orbit (figure 6). The satellite completes 14 orbits a day and covers the entire earth

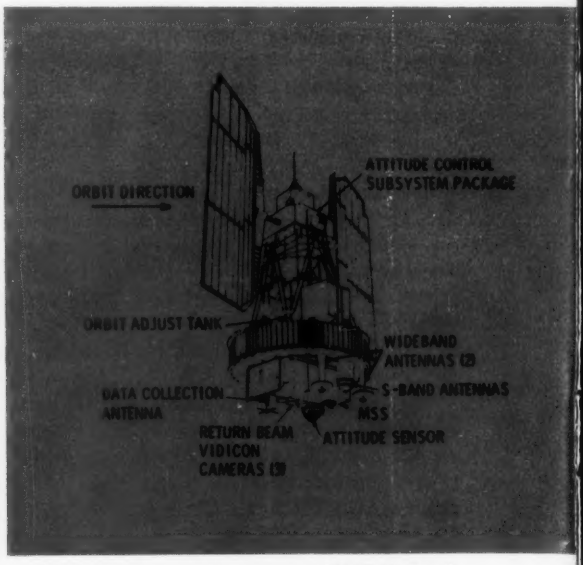
[1]Once acquired, NASA imagery becomes available for public use. Its great advantage is the accuracy of the raw data and the fact that conclusions drawn from analyses of the data can be tested by anyone qualified.

3. This color infrared image of the proposed Tenn-Tom Canal route was obtained during the winter. Physiographic regions, deciduous and evergreen vegetation types and topography may be interpreted from this scene. (NASA)

4. This is a lower altitude image of the same area in color infrared acquired by aircraft in the summer. Using this product it is possible to delineate different deciduous vegetation types and develop a wildlife habitat map. (NASA)



5. Radar imagery facilitates the identification of geologic faults that may affect the route selection for the Alaskan Pipeline.



6. Payload items and components of NASA's Earth Resources Technology Satellite currently in orbit. (NASA)

every 18 days. On board are two imaging systems that sense and record radiation in several visible and near-infrared bands and an antenna that relays local environmental data from remote ground based platforms to data centers on earth for processing and delivery to users.

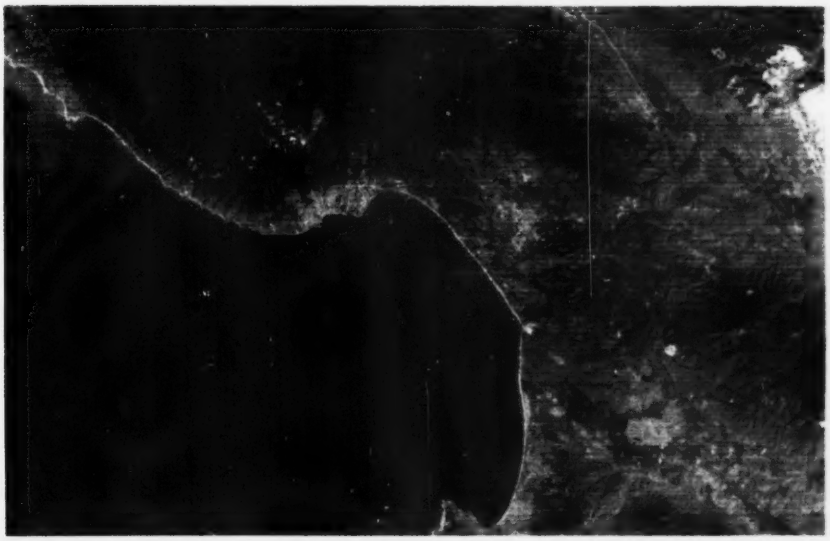
The first of the two imaging systems is the return beam vidicon (RBV). This system is a package of three "television" cameras, each equipped with different filters that restrict passage of the reflected radiation to specific wavelength bands. Each camera is aligned so that it will be viewing identical 100-nautical-mile square portions of the earth at any given time. The products are three images of those features reflecting only blue-green, green-red and red-infrared energy bands in the electromagnetic spectrum.

The second system is the multispectral scanner (MSS), which operates on a different principle. Whereas the RBV takes an "instantaneous" or "still" picture, the MSS continuously records reflected radiation along the spacecraft's flight in a "moving" picture. The MSS has the advantage of producing better quality images although its products are not as geometrically reliable as those of the RBV's.

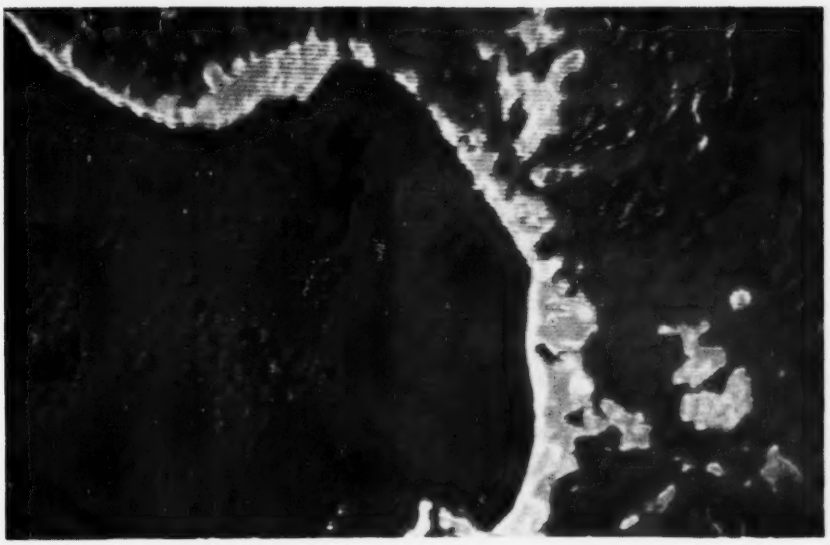
The MSS uses an oscillating mirror to reflect radiation from earth through a series of optical filters that pass only the green, red, red-infrared and near-infrared energy wavelengths, respectively. The energy of these wavelengths is sensed by detectors that transmit this information to the earth based data centers. At the data centers each signal is arranged into one of 64 different intensity levels and each level is recorded on computer tapes that can be used to produce film or computer output products.

There is some redundancy among the wavelength bands selected for these two imaging systems. Since ERTS is only a research satellite, this decision was made to permit comparative evaluation of the systems and to provide a backup capability between the two. The foresight of this decision was evidenced when, soon after launch, the RBV had to be shut down due to a power failure.

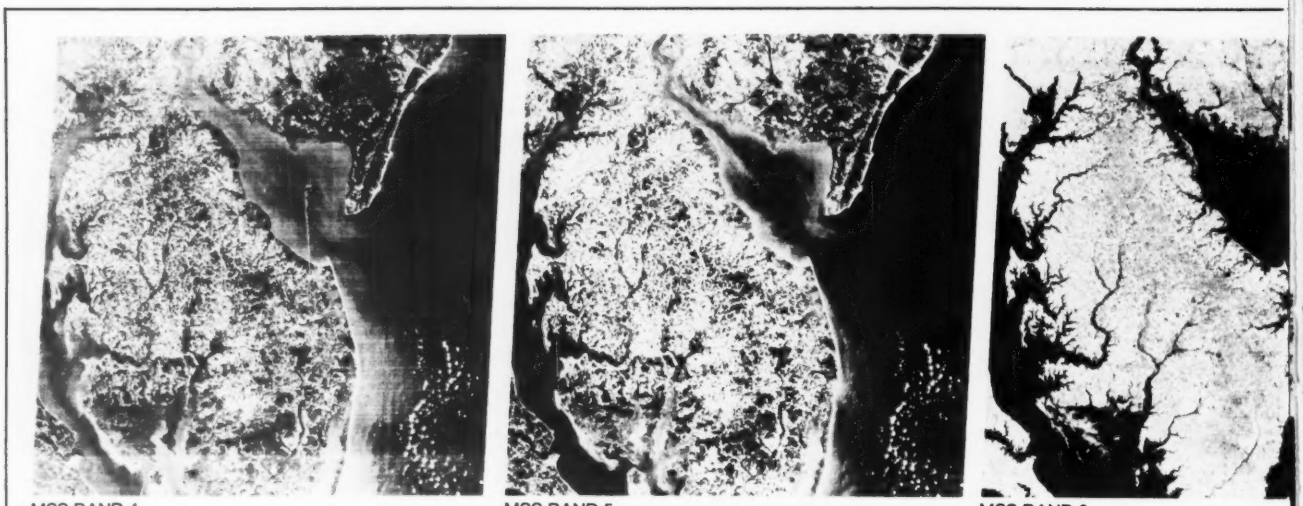
The particular wavelengths selected match certain



7. Satellite image of Monterey Bay, California. Circulation patterns on the Bay may be traced from the differences in sediment concentration.



8. The computer can be used to assign colors to regions reflecting different amounts of energy out to space. The different colors represent different concentrations of sediment in the water.



9. View of the Delaware and Chesapeake Bays in the green, red, red-infrared and near-infrared bands. Band 4 penetrates water the best. Band 5 contains the most cultural information and bands 6 and 7 are useful tools for locating and mapping the extent of water bodies. (NASA)

characteristics in nature that reflect radiation more strongly in some bands than others. For example, water is highly reflective of blue-green energy. Therefore, pictures taken in this wavelength should contain much information on the density of material suspended in water. On the other hand, water is highly absorptive of infrared energy and, therefore, it comes out quite dark on an infrared image. Because of the high contrast between land features and water, the product from this wavelength provides a convenient tool to delineate the boundaries between the two.

The application of these satellite data products by Corps of Engineers researchers is helping to analyze several natural phenomena throughout the United States. For example, the San Francisco District of the Corps is studying images taken over the California coast in an effort to determine movement patterns of sediment along the coastline. Using sediment as a natural tracer, imagery information is being obtained on the changes in nearshore and littoral current patterns, rates of tidal flushing in estuaries and lagoons, and movement of seasonal river and dredging dump discharges.

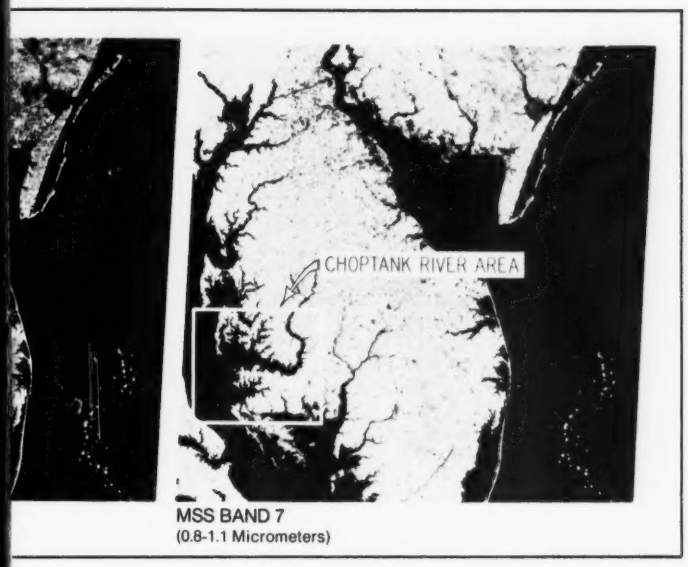
This type of information will aid in predicting the impact of shore-based and offshore structures on the marine environment. The impact of these structures can be monitored over time by ERTS' repeated coverage of the same area. This feature of the system will permit a meaningful evaluation of the accuracy of predictive planning and an improvement of planning methodology.

Color enhancement strengthens the interpretation of this information, a point well illustrated by comparing figures 7 and 8. Figure 7 is a black and white rendition of the energy reflected in the green portion of the spectrum from the region of Monterey Bay, California. This image was produced by assigning a shade of gray to each of the 64 intensity levels recorded on the computer tapes. The lighter gray tones identify those features that reflect more energy in this wavelength band relative to other features. But the task of interpreting this image is immediately compromised by the eye's inability to readily distinguish subtle differences among gray tones.

Since the eye is much better equipped to separate color differences, the obvious solution, then, is to use the undegraded data on the tape to produce a color map of the same scene. The result shown in figure 8 is a spectacular color display that is far more readable than the black and white rendition.

The Waterways Experiment Station (WES) of the Corps has developed yet another technique to facilitate the interpretation of ERTS data. In this case the tapes are used to produce a computer printout of the 64 energy intensity levels. WES has established the feasibility of using data in this format to estimate the sediment concentrations in the Chesapeake Bay area of the East Coast (figure 9).

The approach for this investigation includes acquisition of "ground truth." Water samples are collected in the bay at the time of an ERTS overpass and subsequently analyzed for sediment concentrations. When the tapes from that ERTS overpass become available, data from the green, red and infrared bands are extracted for the smallest resolvable picture element—which is an area with a radius of about 500 feet—and displayed on computer printout. Maps are superimposed on the printout and the locations of the water samples are found. Results from the water sampling are averaged over the nearest four picture elements comprising that area. The intensities of reflected radiation recorded for each band are related to the sediment concentration measured for that area. Other areas having corresponding radiance intensities for each band would therefore have similar sediment concentrations (figure 10).



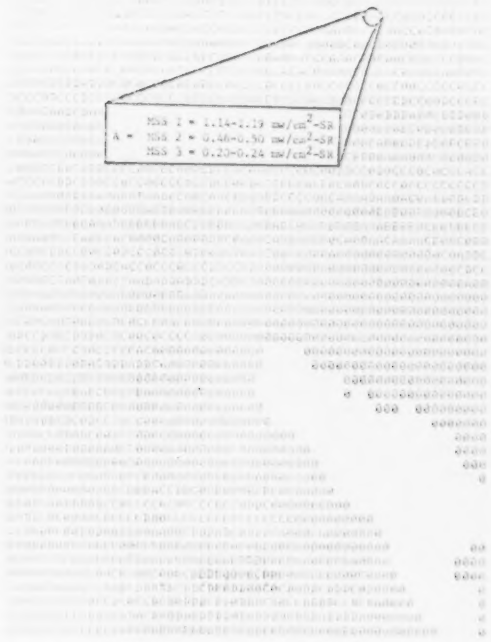
MSS BAND 7
(0.8-1.1 Micrometers)

By completing the analysis in this fashion sediment concentrations for the entire bay may be inferred from only several ground based sampling stations. Obtaining the same information using conventional techniques of data gathering would require literally thousands of boats dispersed throughout the bay. It becomes evident that remote sensing provides a cost-effective method of acquiring these types of measurements for large regions.

The results of this and other ERTS investigations being conducted in the bay will impact on Baltimore District's Chesapeake Bay Study. The main objective of this study will be to formulate a long-term sound water-land management plan for the development and use of the bay area's resources. This task will be facilitated by the completion of a hydraulic model currently under construction.*

Before the model can be used as a predictive tool, however, its ability to accurately represent bay processes must be verified. Remote sensing will provide not only a synoptic perspective of gross circulation patterns in the bay, but also a detailed map of the location, size, and types of the bay's wetlands. Since wetlands act as storage receptacles for large quantities of the bay's water, this information is necessary to assess the effect of these natural buffers on the hydraulic model.

To properly predict the future conditions in the bay, information on current land use activities and rates and locations of land use change is required. The U.S. Geological Survey (USGS) is providing Baltimore District with land use information extracted from aircraft and satellite imagery. The study team recently completed an "Existing Conditions" report for Chesapeake Bay and was compelled to use county produced land use maps. Often this information was outdated and land use classification schemes varied with each locale. The USGS data, in comparison, have the dual advantages of being both recent and consistent.



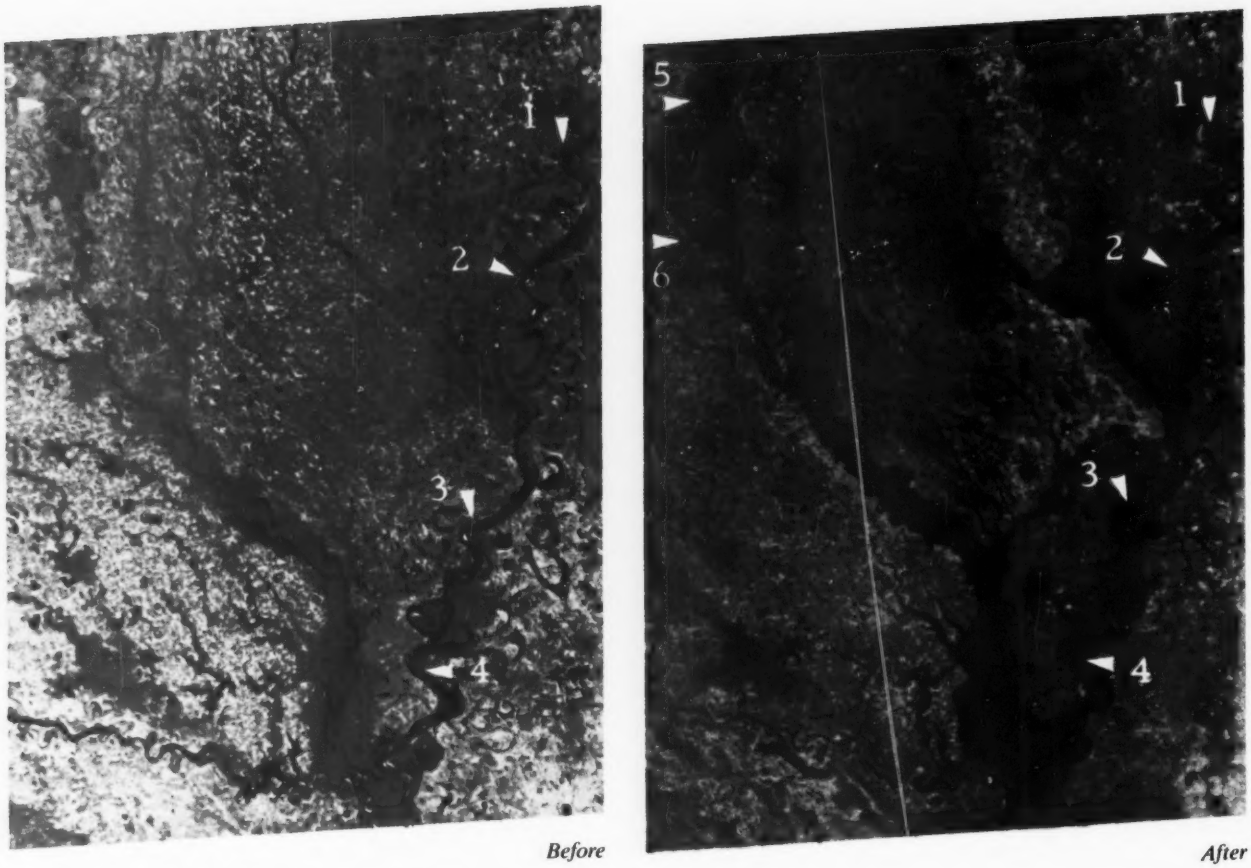
10. Characters in this computer printout represent areas reflecting the same intensity of energy in the different wavelength bands as those areas where water samples were collected. "A" identifies water with 0 to 10 milligrams per liter of sediment. "B" indicates 10-20 mg/l and so on. Land features have been "masked out" and appear white in the printout.

The Corps is also using remote sensing to assess damage due to flooding. This spring the Mississippi Valley was subjected to the effects of the highest recorded water levels in over 200 years. Fortunately ERTS was operating at the time. Post-flood imagery contained information on the extent of damages due to the floods (figure 11). When the timeliness of this system is improved, these data could be used in assigning priorities to those areas requiring disaster relief. They should also be of great help in determining priorities for post-flood restoration work on levees and other protective works which may have been damaged by the heavy runoff.

An analysis of the pre-flood imagery, using the post-flood data as "ground truth," should reveal natural indicators that can then be mapped in other watersheds to delineate the expected extent of flooding waters. ERTS has provided an historical record of the flood and these data, when analyzed, should allow the planner to improve the flood control measures currently employed.

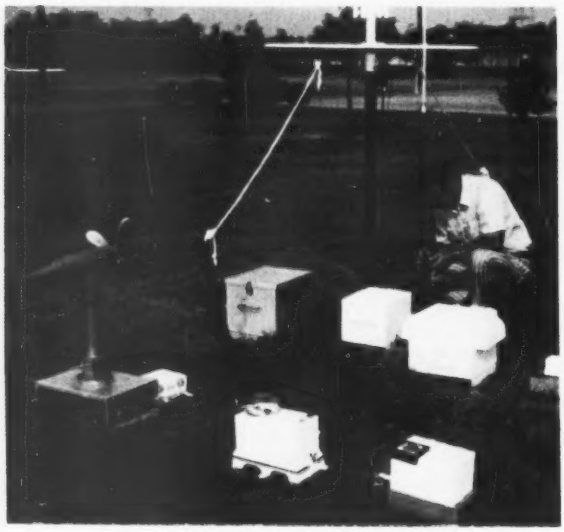
ERTS is also being used by the New England Division (NED) to improve flood predictions. The satellite relays data collected by ground based platforms (figure 12) that report river stage, rainfall, coastal wind and tide information, and water quality parameters throughout the New England area. These data are relayed by the satellite at least twice daily to a data center where they are collated and transmitted back to NED on a near-real time basis. NED is evaluating the performance of this

*See Water Spectrum, Vol. 5, No. 3, 1973, "Model For a Study."



Before *After*

11. Location of those areas affected by flooding waters is facilitated by these before and after ERTS images of Arkansas and Mississippi. Areas that have undergone excessive changes are identified by numbered arrows on both the October 1972 and March 1973 scenes. (NASA)



12. These platforms can collect data on environmental conditions in remote areas on a daily basis, reducing the need for more expensive conventional forms of data gathering. (NASA)

ERTS system by comparing its adequacy with a conventional microwave system currently in operation. The ERTS system has operated through the winter and spring runoff periods and information is actually being used in an operational mode, especially in areas where the conventional system is absent.

Based on the experiences of NED, the feasibility of employing this system in the field has been established. Since ERTS is a research satellite and is therefore not dedicated to supporting operational activities, the only constraint to expanded Corps participation in this aspect of the program is the absence of a follow-on satellite system that assures the continuity of data collection.

The Corps' Civil Works Directorate is currently assessing this program for its integrity and applications potential. On the basis of the projects described here it seems evident that NASA's investment in remote sensing technology has resulted in a number of beneficial uses. Corps field elements have made critical suggestions as to the future employment of these tools; and continued evaluation of these exotic forms of data gathering with respect to conventional methods should result in wider application of remote sensing techniques to the planning process.■

"Almost every water study begins with the premise of scarcity. Is this premise fact or myth?"

MYTHS

Cornerstones for Counterpositions

by Harold M. Stults, Ph.D
Economic Research Service
U.S. Department of Agriculture

The history of development, management and use of water resources in the United States is a fantastic success story. The development of large quantities of water suppliers has played an important role in the economic development of the United States. Irrigation development has transformed areas of low productivity into some of the most productive lands in the United States. While millions of people throughout the world have gone hungry, the United States has had an abundance of high-quality, low-cost food. Exports of agricultural products have an important effect on our balance of payments. Water developments also provide power, recreation and flood protection. Many viable, productive communities exist because of water development.

But, in spite of all that has been accomplished, nagging questions and controversies keep arising. Counterposition views seem to be increasing in numbers and gaining greater strength. The wisdom of simultaneously carrying out public programs for resource development and for cropland retirement has been questioned many times. Acts of development alleged to be in the public interest are viewed by others as atrocious crimes against nature. Some groups prefer zoning people out of the flood plains rather than building expensive flood control structures. Projects have been stopped or delayed, and studies terminated.

In view of the rapidly changing environment facing water planners, perhaps this is the time to critically appraise how we plan the development, management and use of our natural resources.

This article discusses water myths or false images that influence public attitudes about water, examines some of the constraints on water planning, discusses the impact of uncertainty in planning, and outlines an approach to planning that would lead to better planning decisions.

Myths and False Images

Water is unique in several ways. Because it flows, quantity and quality changes resulting from its use at one place and time may affect other uses at other places and times. These *externalities* are an important characteristic of water resources. Water also has a *cyclic* peculiarity. Its supply is generally replenished continuously through the hydrologic cycle. It generally is not consumed in use. Rational planning requires that these objective traits of water be considered in establishing policies and programs for water use.

But the *water-is-different* images often ascribe to water peculiarities that go far beyond its objective characteristics. They appear again and again in our water planning reports, issue papers, and everyday conversations. As planners for public agencies, it is in our own self-interest to recognize these false images and become more realistic about water and its role in society.

Scarcity: The most realistic concept of scarcity is the use made of the term by economists. Scarcity is the relationship between the supply and demand of a good or service as reflected by its price. If the demand is large relative to supply, the price is high and the good or service is considered very scarce (diamonds, Picasso paintings, or vintage wines). When the supply is large relative to demand, the produce is less scarce and the price is cheap.

The term "scarce" is probably used more often to describe water than any other commodity in the United States. Almost every water study begins with the premise of scarcity. Is this premise fact or myth?

As measured by its price *water is the cheapest of all commodities* marketed in the United States. It is the least scarce of all the things we buy. There is nothing in the market cheaper or less scarce than water. We have all heard the expression "dirt cheap." The price of dirt in the Denver area is about $1.50 per ton. Delivered, it runs around $2.00 per ton. Water is delivered to Denver homes on demand, 24 hours a day, 365 days a year for about 14 cents per ton (56 cents per 1,000 gallons). In Central Arizona, where the water scarcity is often labeled "critical," water is delivered to Salt River Project farmers for about $.0015 per ton ($.000006 per gallon).

There is little basis for special selection of water as a scarce commodity when it sells for 165 gallons for one penny—delivered! It does nothing for objective water planning to single out the least scarce of all commodities and tag it with the scarcity label.

Free Good: In direct conflict with the scarcity image is the "free good" image. It holds that water is a "free gift

---

Dr. Stults is the Economic Research Service representative to the Western U.S Water Plan Study. The viewpoints expressed are those of the author and do not necessarily reflect those of the Economic Research Service or the Department of Agriculture.

DRINKING WATER
Is water a "priceless" resource?
Is water necessary for "survival" of mankind?
Is irrigation a necessary condition for growth in the West?

of nature" so should cost its user no more than the net cost of its production and delivery. This implies an unlimited supply, free at its source, a complete absence of scarcity. Many people apparently hold the scarcity and free good image at the same time.

Survival: Water is necessary to life and essential for sanitation. It is a survival absolute. Without it, we die. Man must have a couple of quarts of water per day to survive. It is not necessary for survival, however, that every person have 200 gallons per day or that another irrigation project be developed.

A major public official speaking in support of a large irrigation project states: "Water is life. We must have water to survive. The question is not whether or not we need this project. The only question is, how do we get it?" This kind of attitude is not unusual, even among planners, and presents a major obstacle to rational water planning.

Priceless Resource: Closely related to the scarcity myth and the survival image is the priceless resource image. Because water is necessary for survival and people would pay almost any price rather than go without, development of water is often viewed as providing this priceless resource to consumers. Yet, not a single planning decision we make today is relevant to survival or to providing "priceless" water. Most of our decisions are relevant to providing water at a cost of under 15 cents per ton, as discussed earlier.

Irrigation Fundamentalism: Based on the concept that agriculture is the cornerstone of any viable society and that, in an arid environment, irrigation is either required or is highly beneficial for crop production, this image holds that in much of the West, irrigation is a requirement for a viable society. While it is true that, in the past, many communities developed around an irrigation economy, only a fraction of future Western economic growth is expected to be associated with irrigation development. This is not to say that the growth of certain local communities will not be tied closely to irrigation development; only that irrigation is not a necessary condition for viable growth in the West.

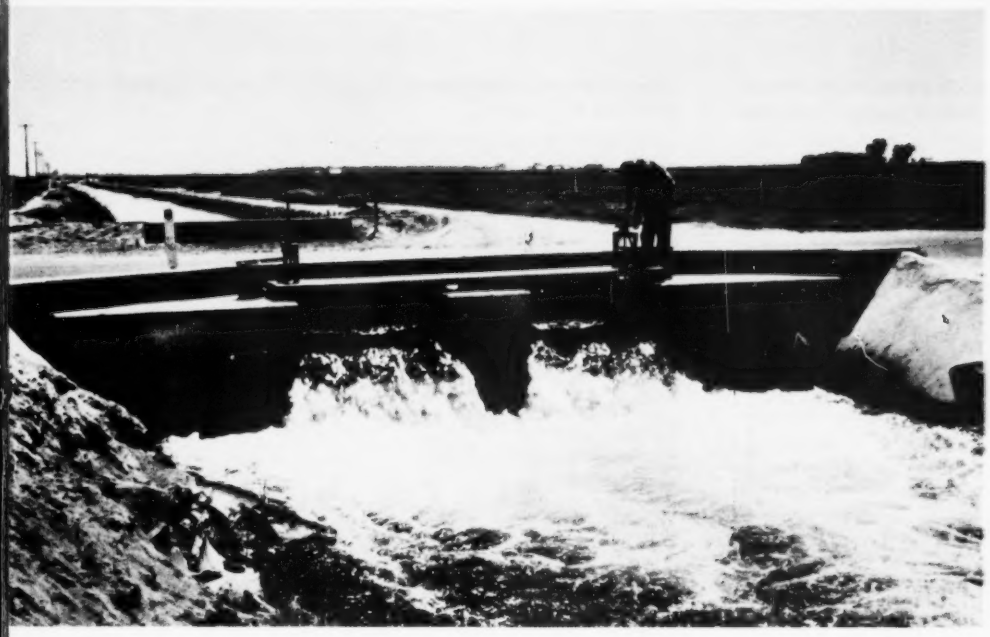
Environmental Quality: The newest, but fastest growing, of the absolute images of water is in the environmental quality-recreation areas. The idyllic idols of open and green spaces, parks, playgrounds, greenbelts, recreation, camping, and wild rivers are lining up along with other water uses in establishing water *requirements* for these purposes and demanding their share of water resources.

Implications

These myths and false images interact with each other and with the realistic images and reflect the public policies and institutions that guide the control, development, and allocation of water resources. As a result, each user of water views his desires for water as *water requirements.* But, except for a couple of quarts per day, they are *not* requirements. They are *preferences* and should be viewed as such. We do not have irrigation requirements,

Big Surf, Arizona's ocean in the desert, also demands its share of water resources—some 4 million gallons of treated water recirculating in a 20-acre lagoon.

Steam and fluid from a geothermal well symbolize as yet untapped groundwater supplies in areas where surface supplies are fully developed.



Is enough effort made to divert irrigation water supplies to other uses?

instream requirements, or municipal and industrial requirements. We do have preferences or demands for these uses of water.

The almost total insulation of water from the market mechanism tends to reinforce the image that man's desires for water are absolute water requirements, rather than demands that are relative values. The absence of price signals tends to reinforce the "free good" image and leads to the development and allocation of water as if it were free at its source. Administrative rules and regulations are used in lieu of prices. Rigid, unresponsive administrative practices lead to inflexibilities in water allocations. This leads to an overemphasis on security of water rights and rigidity and inflexibility in the allocation of water among users. Water-users emphasize security at the cost of flexibility, and thus policies and institutions emphasize tenure and rigidity rather than the flexibility required to achieve equity and efficiency in water allocation.

The inevitable outcome is that we have much economic inefficiency in water allocation over space and time—inefficiency in the allocation of water in the short run between uses and between users, and inefficiency in the commitment of development capital to long-run water uses and allocations.

Historical patterns of water allocation and past relative preferences among water uses get locked into distribution patterns of water because of resistance to transfer and the lethargic character of the institutions by which such transfers are possible. Although initial water allocations may have been efficient at the time they were made, they have steadily diverged from efficiency goals as demand and technology have changed at ever increasing speed.

In the West, where most water development is tied to irrigation, the inflexibility of water transfer has hastened the development of remaining unused supplies, even to the extent of importing water at high costs to satisfy growing demands. At the same time, little effort is made to divert irrigation water supplies to other uses in spite of the general abundance of agricultural production. The result is an ever increasing cost of water development and transport, insulated against lower cost competition from local water transfers between uses, users, and locations.

In areas where surface supplies have been fully developed, development has often turned to groundwater as the cheapest available additional water supply. This results in the depletion of a stock resource that in most cases is irreplaceable. Depletion of a stock resource is not bad in itself. The tragedy is that we are depleting it now instead of saving it for efficient use later. At the same time we are using our surface (flow) resources inefficiently because of false images and the resulting inflexible institutions and policies.

As long as society perceives the false images of water described in this article, there is little that we as water planners can do to improve the situation. Society's "unseen hand" prescribes the policies and institutions—defines the rules—of the water game. Rational action calls for playing the game according to the rules established by society.

But, we *are* in a period of change. Water attitudes and values of society are changing. As new supplies of water become increasingly scarce, conflicts increase and society reassesses its attitudes. New rules are being established. For instance, environmental objectives are being considered, more alternatives are being examined, demands are being evaluated, and traditional planning approaches are being challenged. If we want to continue

in water planning, we need to continue to develop rules for planning that reflect society's changing attitudes and values.

Uncertainty

As if the problems of working in an area filled with myths, false images, and widespread inefficiency were not enough, planners also must contend with uncertainty. It is highly unlikely that the conditions on which water requirements for the year 2000 would be based will be reasonably close to actual conditions. In fact, the statistical probability of this situation approaches zero. Said another way, when we make economic projections and establish water requirements to meet these projections, we are almost certainly planning for the development of the wrong quantity of water.

For example, in establishing irrigation water requirements, if there were three equally likely but significantly different population growth rates, three levels of exports, three consumption patterns, three patterns of regional development, three levels of yield growth and three levels of water use per acre, there would be 729 equally possible future situations. The same kind of situation exists for the many other uses of water. Taken all together, the water requirements approach to planning will likely result in planning for a situation that will not occur. A different approach to planning is needed. The new approach must go beyond simply developing a new set of terms for the same old practices.

Better Decisions

The intent of this essay is not simply to criticize past mistakes but rather to establish the background for proposed changes in water planning that can lead to greater efficiency in planning for the development, management, and use of our natural resources. Two major changes are proposed: (1) stop planning to meet water requirements and start planning to meet the demands of alternative futures, and (2) stop developing a long-range plan and begin developing a planning process that continuously provides current, reliable intelligence to decision makers. Specific recommendations follow:

Planners should utilize every opportunity to *broaden the scope* of planning to include total resource planning. The ties between land, water, and environmental resources are so strong that planning for a single resource often results in serious negative external impacts on other resources or institutions.

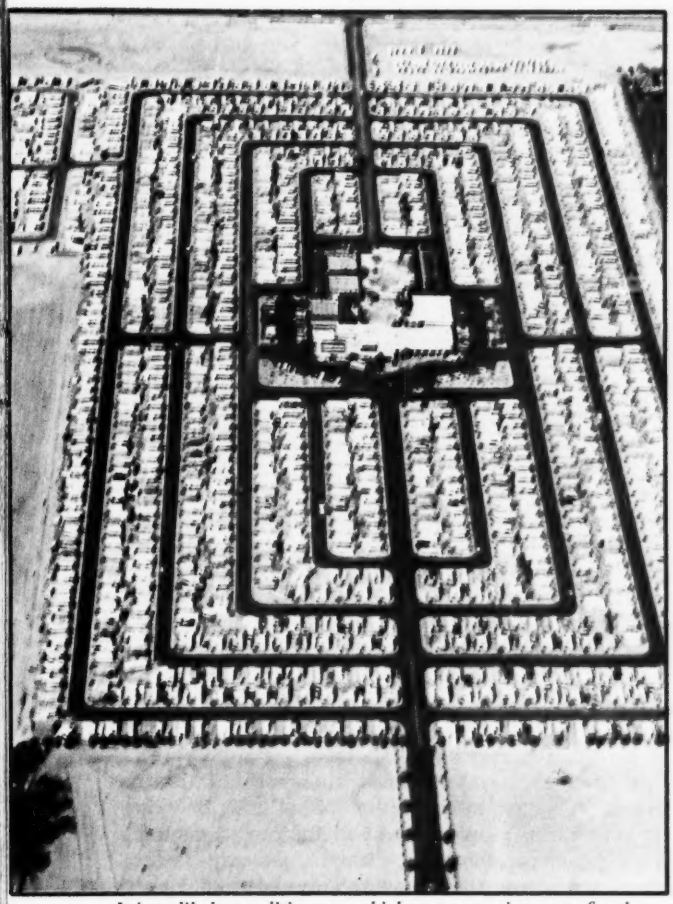
It is not enough to simply identify these impacts. Rather, the objectives of land, water, and environmental planning must all be integrated into the planning process, and significant trade-offs must be identified for the relevant range of alternatives.

Much more effort must be expended in measuring the demand schedules for the products that use water as a major input against the corresponding derived demand schedule for water.

In other words, we must measure the *preferences of society* for varying quantities of water for major uses by estimating the price society would be willing to pay rather than go without. It is especially important that these preferences (prices) are identified over the relevant range of possible quantities of water available. This is required in order to analyze the marginal impact of varying quantities of resource use. Major errors in estimating the effect of alternative courses of action are made by estimating average rather than marginal values.

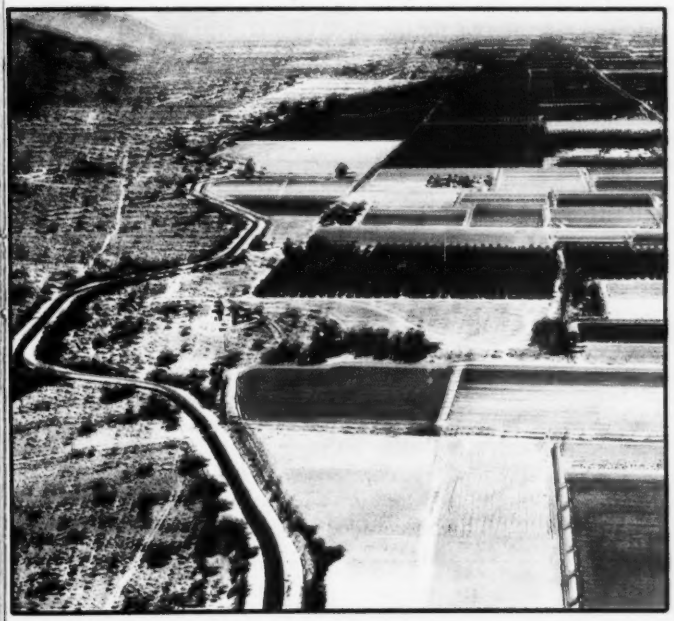
Planners must begin to utilize *economic projections* as a tool for evaluating alternative futures by (1) providing insights into the nature and level of future economic activity; (2) identifying potential problems or inadequacies

Traditional planning approaches lead to situations similar to that below and are being challenged.



It is unlikely conditions on which water requirements for the year 2000 would be based will be reasonably close to actuality.

The end result is an improved society rather than another project.



in resource supplies; and (3) providing a baseline, or measure, against which alternative plans can be tested. The distinction between the above and the traditional approach is more than semantics.

The recommended approach is to stop viewing regional market shares and associated water requirements as an indication of needs that must be met—stop viewing economic projections as providing a goal or target—and begin to utilize projections as a tool in an analytical framework designed to measure impacts of alternative plans. There is no single fixed quantity of water supply to plan for. Rather, there is a range of resource development management and use alternatives, each with a different set of economic, environmental, and social consequences. Planners should be concerned with reliable measurement of these consequences.

Total resource planning is an extremely complex business. The only way to adequately consider all of the relevant relationships is to make a major commitment to the development and use of *systems analysis* as an important tool in planning. The system should be structured so that independent component models can be added to or taken from the system without disturbing the operation of the system. The system should be designed to simulate alternative futures, to measure economic and social consequences of each alternative, and to display these consequences in the multi-objective accounts.

Uncertainties should be explicitly recognized and efforts taken to reduce them. This can be done by statistical analysis, testing of models—both physical and economic—and, in some cases by developing and evaluation of prototypes.

While much can be done to reduce uncertainties, they cannot be totally eliminated. In order to avoid costly errors that may be caused by uncertainties, the planning process must be designed to provide maximum flexibility. This requires that alternative futures and alternative solutions be continually evaluated.

The planning process must be structured so as to provide information at the proper time. Many long-range alternatives do not require current decisions other than to avoid a decision that would exclude a specific alternative some time in the future.

The planning process should employ a sequential decision-making approach. This approach identifies the critical point in time when decisions must be made, and directs the planning process to provide the information needed to make those decisions.

Planners must recognize that the end result of planning is not another project but rather an improved society. There are many ways we can develop, manage, and use our resources to achieve this goal, including changes in policies or institutions, increased efficiency, and better conservation and preservation of resources. We need to broaden our method of analysis to include these future alternatives on a par with engineering solutions. Proper planning demands equal attention to both.■

Low permeability soils and wetlands are best suited to the overland flow method of land treatment of wastewater.

by P.G. Hunt, Ph.D

OVERLAND FLOW

Land *treatment* with wastewater is not the same as land *disposal.* In land treatment, the volume and loading capacity are adjusted to fit a particular soil.

Three methods appear to be the most practical: crop irrigation as described in Vol. 5, No. 2; rapid infiltration to be in a subsequent issue; and the method discussed in this article.

Few Americans remain unaware today of the serious water pollution problems facing this country. The awareness means most of us are giving at least tacit support to wastewater treatment. However, most of us view prevention of water pollution and restoring use of America's waters to the public for fishing, boating, swimming, and pleasant viewing as the more tangible goals of treating wastewater. Reversing detrimental ecological shifts is probably viewed as a less tangible but equally important goal.

The public is generally aware that a major effort is underway to construct *secondary* treatment facilities. It is, however, less aware that these facilities are primarily designed to reduce the organic load or biochemical oxygen demand (BOD). Serious polluting constituents still remain in secondarily treated wastewater.

Secondary treatment plants are quite efficient at BOD removal. Removals of 80 to 90 percent are common. Actual concentrations of BOD in water leaving a secondary plant will vary from 10 to 50 parts per million.

It will be rather discouraging, though, when communities realize that other types of serious pollutants will still remain in water coming from their newly constructed treatment plants. It will be even more discouraging when they discover that it will be more costly and complicated to achieve the final or tertiary level of treatment than it was to achieve the secondary treatment. But despair need not overwhelm the community once it learns the answer to the question: "What serious pollutants remain in secondarily treated wastewater?" Seemingly they must be rather environmentally unusual or complex to require such extensive and costly treatment. However, these pollutants are generally nothing more than chemical fertilizers.

They are the nitrogen, phosphorus, and trace elements for which American farmers spend millions of dollars per year to fertilize agricultural land. As was stated in a previous issue of Water Spectrum,* secondary treatment removes only about 20 and 30 percent of the nitrogen and phosphorus, respectively. Although 60 to 80 percent of the trace elements are removed, their concentrations are still high enough to be potential polluting or stimulating agents. A logical question for any community aware of these facts is: Can secondarily treated wastewater be given advanced treatment by placing the water polluting constituents of lakes and streams on agricultural land? The answer: *secondarily treated wastewater can be treated to an advanced level on the land in many locations.*

However, answering the questions of what type of land treatment should be used or whether land treatment is even practical for a particular area is complicated. This is primarily because such questions encompass sociological and economical as well as technical factors. For example, while it might be technically feasible to pipe wastewater hundreds of miles to and from a land treatment site, it would probably be economically infeasible. Therefore, for the sake of simplicity and clarity, this article will attempt to address only the technical concept of land treatment.

To start with, an important point to remember is that land *treatment* of wastewater is not synonymous with land *disposal.* Land disposal is simply the placement of wastewater on the soil with little regard for the level of water renovation or crop response. Land disposal might be described quite accurately as an "out-of-sight out-of-mind" practice. But in land treatment, the hydraulic volume and nutrient loading rates are adjusted

Dr. Hunt is Soil Microbiologist/Agronomist in the Office, Special Assistant for Environmental Studies, U.S. Army Engineer Waterways Experiment Station.

*See "Sludge Recycling: The Most Reasonable Choice" in Vol. 5, No. 1, and "Water Renovation for Unrestricted Re-use" in Vol. 5, No. 2, 1973.

to fit the treatment capacity of a particular soil system over an extensive period of time.

The three most commonly discussed divisions of land treatment are based on hydraulic capacity. These are referred to as *rapid infiltration, crop irrigation,* and *overland flow.* The rapid infiltration systems are capable of treating a number of feet of water per day for groundwater recharge. This water can later be pumped to the surface and used for recreational ponds or crop irrigation.

The crop irrigation systems are normally capable of treating one to several inches per week with the actual rate of application based on the renovative capacity of the particular soil and crop used. Renovated water may be collected in a drainage system and returned to a specific stream or reused for industrial purposes or it may be allowed to slowly filter into the groundwater or nearby streams.

Overland flow systems are normally capable of treating one to several inches of wastewater per week, depending upon environmental conditions. Terraces and natural streams make up the collection system for overland flow as most of the water does not penetrate the soil surface. The remainder of this article will deal specifically with overland flow treatment of wastewater.

As previously stated, the overland flow method is the treatment of wastewater on soils of rather low infiltration capacity. It differs from crop irrigation and rapid infiltration in that overland flow's treatment is primarily a soil surface phenomenon and soil microorganisms are more active in the treatment.

The slope of an overland flow site must be great enough to prevent puddling, but not so great that wastewater rushes from the site without treatment. (Two to six percent ground slope is normally best, with treatment slopes being 150 to 300 feet in length.) A cover crop is also an integral part of an overland flow system, since the plants remove substantial amounts of nitrogen and phosphorus in the form of plant protein and also prevent erosion. Terraces at the end of treatment slopes also prevent erosion and concurrently channel purified water from the treatment site to collection streams.

One of the principal advantages of an overland flow site is that renovated water can easily be monitored and sampled as it leaves the site. This allows a high degree of confidence to be placed in the ongoing treatment process.

As wastewater passes over the surface of an overland flow system, it comes into contact with a vast number of microorganisms, plant roots and stems, and soil surfaces. These components interact with the wastewater and each other in the process of treatment. It is the particular manner in which these components interact that makes an overland flow system function. In general, nitrogen is removed by the plants and microorganisms and phosphorus is removed by the plants and the soil. Trace elements are also removed by the plants and soil but the soil contributes most to their removal. Nitrogen removals as high as 86 to 98 percent and phosphorus removals of 50 to 75 percent have been reported for overland flow treatment. Trace element removal is also high, normally greater than 90 percent.

In overland flow, the soil is flooded with wastewater during the application period, and is subsequently under anaerobic (lack of oxygen) conditions. Under these conditions, microorganisms called *denitrifiers* convert nitrate, a soluble polluting form of nitrogen, into elemental gaseous nitrogen. Since the atmosphere is approximately 80 percent elemental nitrogen, this is an environmentally desirable process. The plants are able to utilize the remainder of the soluble nitrogen, most of which is removed from the treatment site and recycled in the form of plant protein. The exact extent to which

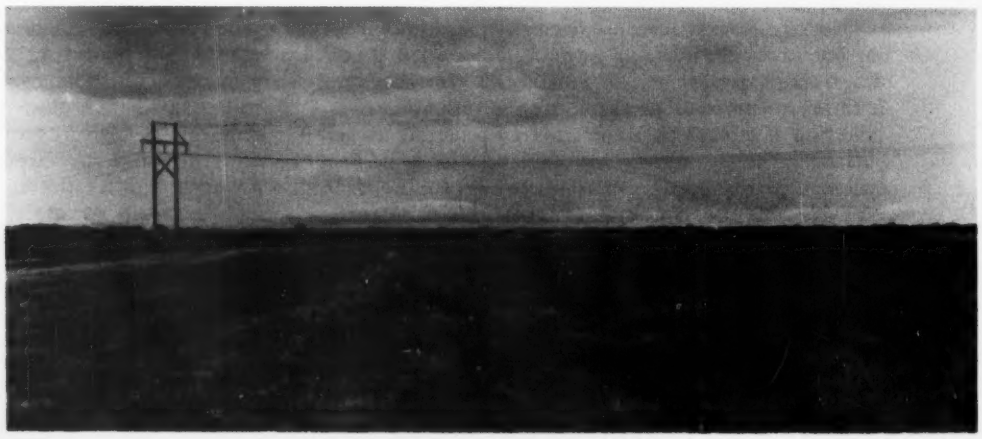
This isometric drawing depicts an overland flow wastewater treatment system.

denitrification can be utilized in an overland flow system has not yet been shown, but research strongly indicates it is significant enough that nitrogen removal is not the limiting factor in designing an overland flow system.

Two obvious questions about flood-generated anaerobic conditions are: how do the plants survive without oxygen, and what prevents offensive odors? The first answer is quite simple. Plants that are tolerant to both flooding and the absence of soil oxygen must be used. Such plants obtain their oxygen by passing it through their leaves and stems to their root systems. Such a capability is common among wetland crops and marsh grasses.

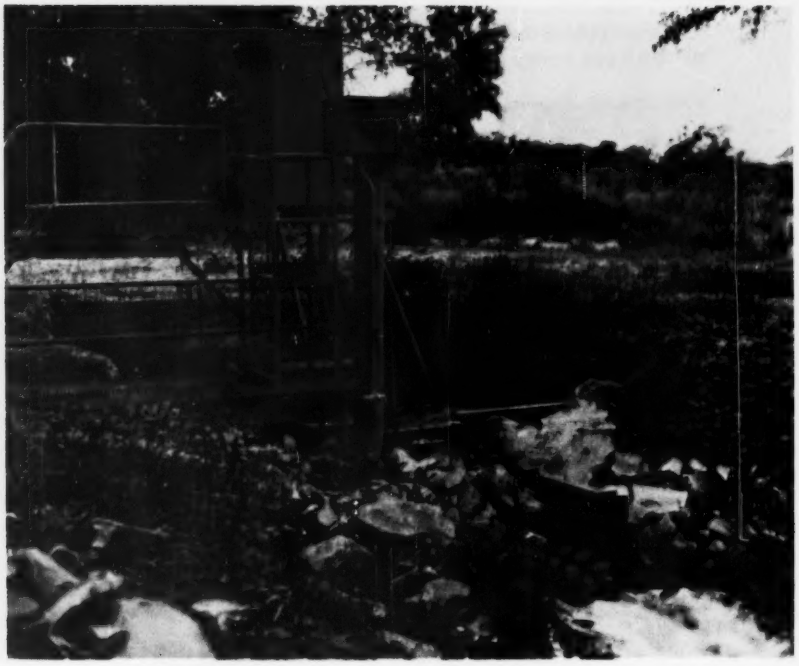
Offensive odors are prevented by the fact that the overlying layer of wastewater is not anaerobic and the system is oscillated between anaerobic and aerobic (oxygen present) conditions. In fact, it is this oscillation that makes an overland flow system so versatile, since the processes of interaction by both aerobic and anaerobic microorganisms can be utilized.

Removal of phosphorus is normally the limiting factor on a short-term basis, while accumulations of either heavy metals or phosphorus may be the long-term limiting factor (50 years or more). The rather low efficiency of overland flow systems in phosphorus removal is somewhat surprising considering the fact that many of the soils on which overland flow systems are placed are low pH clays with high concentrations of iron and aluminum. Since iron- and aluminum-phosphorus complexes are quite insoluble, these soils are normally extremely efficient in phosphorus removal. However, the



This particular system of gentle slopes, grass cover and clay soils has been used for overland flow by a Paris, Texas, cannery since 1964. Wastewater sprays are barely visible at top of the slope.

Besides the visible flow paths, a thin layer of wastewater is passing through the organic mat of grass debris.



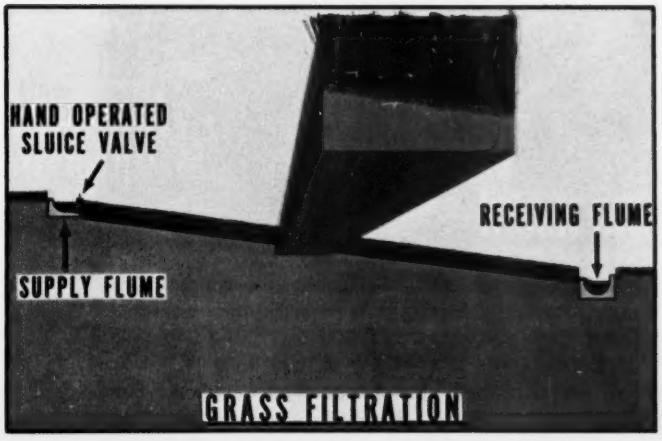
Approximately 80 percent of applied wastewater flows off the site. Its quality can be monitored at stations such as this one.

overland flow treatment is primarily a surface reaction. Therefore, much of the subsoil high iron-aluminum clay surface does not come in contact with the wastewater-contained phosphorus.

In addition, phosphorus complexes are generally more soluble under anaerobic conditions than aerobic conditions. Therefore, much of the management of an overland flow treatment system is involved in maintaining conditions that are suitable for good phosphorus removal. This is one of the areas in which significantly more research is needed.

Most of the trace elements—such as zinc, copper, boron, and mercury—appear to be removed rather efficiently by overland flow treatment. Unfortunately, it may be this very efficiency that will limit the long-term life of an overland flow system, for only the upper few feet of soil can easily be incorporated into the active surface layer by conventional plowing. In addition, the plants do not remove significant quantities of these elements from the soil.

The question of trace elements is one of substantial controversy and certainly a much clearer understanding of their effects will be obtained before they are likely to become a problem in an overland flow system. Before then, tighter ordinances on the quality of material that may be dumped into metropolitan sewers may greatly reduce the concentration of trace elements.



Overland flow treatment has been used primarily for the treatment of cannery wastewater in the United States. It has, however, been used for the treatment of municipal wastewater from Melbourne, Australia, for 50 years.* In Melbourne, the process is referred to as "grass filtration."

To obtain overland flow, the soil must have a low permeability. This normally restricts the system to clays and silts. In addition, the soil surface must be smooth enough for the wastewater to flow somewhat uniformly across it rather than following restricted channels. Research indicates that thin uniform layers of flowing wastewater promote the most efficient treatment. This often necessitates substantial earth work with subsequent higher construction cost. Yet, under certain conditions, rather dramatic earth work may be justified because the alternative may be an even more expensive and complicated process. More common, however, are situations where only moderate leveling, sloping, and terracing are required. Quite often agricultural fields located on slopes or previously prepared for wetland crops would

Billions of microsites provide renovating biological action as the wastewater flows over the surfaces of this intense plant cover.

The algae forming this algal mat constitute only one group of renovating microorganisms. They will reduce treatment efficiency if allowed to develop extensively.

The Metropolitan Board of Works Farm at Melbourne, Australia, uses overland flow to treat raw sewage.

need only minimal earth work. It is these agricultural lands that will most easily accommodate the overland flow treatment of wastewater.

Since intimate contact with the soil and free diffusion of nutrients and oxygen through the overlying liquid layer are required, overland flow treatment is particularly unsuited for frozen conditions. Additional cold region handicaps would be a rather inactive microbial population and substantial damage to the cover crop. Yet, this does not completely eliminate the use of overland flow in northern areas. The wastewater can be stored in a large lagoon during the winter and treated during the summer.

In fact, the storage of wastewater for a significant period in a two-celled lagoon in any latitude has the secondary advantage of providing the necessary die-back time for pathogens that have been removed from their host. Furthermore, if wastewater is chlorinated upon entering the lagoon, then treated with ozone upon leaving, we would have a threefold public health safeguard. This is substantially more than most States are requiring at this time.

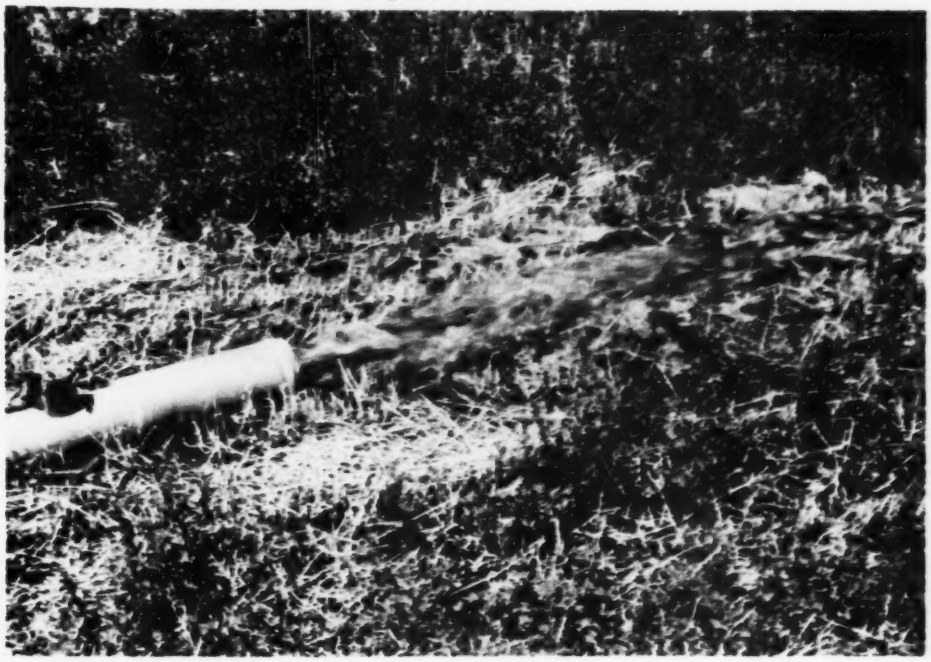
The following concepts of applying overland flow principles to wastewater treatment in wetland agriculiure are concepts and not proven methods of wastewater treatment. In addition, it should be emphasized that none of the Corps' studies are as yet recommending their adoption. Considerable research will be required before that point can be reached. However, land treatment in association with wetland agriculture is one that has great potential. Wetlands and impermeable soils have too long been disregarded as having little potential for wastewater treatment.

Probably the best known and most important wetland crop is rice. It is grown rather extensively in Louisiana, Texas, Arkansas, and California. One of the most costly and limiting aspects of rice growth is water. The cost of water is commonly 20 percent of the cost in producing a rice crop. Additionally, the lowering of the groundwater by pumping from wells is an ecological problem of considerable magnitude in many coastal areas. Water for rice could become a problem at any price and, obviously, is the current limiting factor in many areas. Along with the water cost, rice growers have the usual problems of fertilizer cost and availability.

What does this have to do with the advanced treatment of wastewater? The answer is potentially a great deal, for the rice field is very similar to the surface of an overland flow system. In addition, the biological and chemical processes of the two systems seem to be similar. The loss of nitrogen by *denitrification* has long been recognized as a problem to the rice grower. This historical liability could be turned into an asset for wastewater treatment.

The rice crop also has a need for phosphorus and trace elements which could be supplied by wastewater. However, phosphorus is not as readily removed by the soil under the flooded conditions associated with wastewater treatment as would be possible in an aerated soil. Thus, the removal rate of phosphorus would probably be the limiting design factor for wastewater

Border irrigation of alfalfa in the U.S. using secondary effluent which adds nutrients to the soil while treating the wastewater.



treatment in a particular rice field. As pointed out in an earlier issue of Water Spectrum, soils containing so much phosphorus that they can no longer effectively remove phosphorus from wastewater are quite valuable from the agronomic standpoint.* Thus, these wastewater-treated soils would appreciate in agricultural value.

The rice growing areas, in particular, have another attractive characteristic in possessing existing water-delivery systems. Capital expenditure for pipe, pumps, etc., would be much less than in areas where irrigation has not been used extensively. Substantial treatment benefits might also be obtained from the grass and algae growing in canals leading to and from these rice fields.

Probably the most obvious objection to applying this concept to rice production if the wastewater were probably would not be a problem if the wastewater were chlorinated, stored for greater than 90 days, given an ozone treatment before flowing onto the fields and if the rice was heated both during the drying period and before consumption. The health aspect is, however, a central question that will have to be answered.

Sugar cane and sorghum are two more crops with which the intermittent flooding used in the overland flow treatment might be compatible. The similarity between the cultural practices used on these crops and the classical overland flow systems is, however, not so apparent and some significant cultural adjustments would probably be required.

In addition to the cultivated crops of the wetlands, natural marshes have significant wastewater treating capacities. In these areas, denitrification, plant uptake, and soil incorporation are quite active. Several universities are presently investigating the potential of these natural areas for wastewater treatment. However, such questions as containment of the added nutrient and species compositions and development will have to be answered before these areas can seriously be considered for significant treatment of wastewater.

Although overland flow has not been used as extensively as rapid infiltration or crop irrigation, it appears to be a sound method of treating wastewater to advanced levels. Certainly, there is as much information and experience concerning overland flow treatment of wastewater as there is for many other forms of advanced treatment of wastewater presently being considered by municipalities and wastewater treatment consultants. Consequently, any municipality with substantial areas of low-permeability soil in reasonable proximity to the metropolitan area should consider overland flow as an advanced wastewater treatment alternative.■

See previous footnote

PRINCIPLES AND STANDARDS: The President's Announcement

On September 10, 1973, the U. S. Water Resources Council published the controversial "Principles and Standards for Planning Water and Related Land Resources" in the "Federal Register." President Nixon, in announcing his approval of the new Principles and Standards, said, "They represent the culmination of several years review by the Water Resources Council to develop improved planning criteria to achieve our goal of wise use of the Nation's water and related land resources with full consideration to the protection of our environment." The new Principles and Standards represent a marked departure from past resource planning, and will systematically relate all aspects of water and related land resources planning to economic and environmental planning criteria. In addition, where appropriate, effects on regional development and social well-being will be displayed.

Events Leading to Adoption

The Water Resources Council began its review of Principles and Standards for planning water and related land resources in 1968 to carry out one of the important Congressional mandates of Public Law 89-80, the Water Resources Planning Act.

In 1969, after a preliminary report of a Special Task Force had been prepared, the Council held 10 public hearings to solicit the views, recommendations and comments of the public on the preliminary report. The Task Force's preliminary report was also widely discussed and reviewed during late 1969 and 1970 at various meetings and seminars and by numerous organizations and individuals both within and outside of the Federal Government. In addition, the proposals contained in the preliminary report were subjected to extensive analytical testing during this period.

After careful consideration of the final recommendations of the Special Task Force submitted in August 1970, the Council published proposed "Principles and Standards for Planning Water and Related Land Resources" along

---

In the last issue we promised further coverage of the revised Principles and Standards for water planning. A few days after the President signed the revised document we visited the Water Resources Council to discuss selected topics, particularly for comments on . . .

2 OBJECTIVES 4 ACCOUNTS

by Warren D. Fairchild,
Director, U.S. Water Resources Council

with a separate draft Environmental Statement on the proposed Principles and Standards in the "Federal Register" on December 21, 1971, (36 F.R. 24144) for a period of public review and comment, commencing on December 21, 1971, and terminating March 31, 1972. Notice was also given that as part of the review, a public hearing would be held at the National Museum of History and Technology in Washington, D.C., March 20 and 21, 1972. Reaction to the notice and publication of the Council's proposals prompted the Council to announce and hold additional public hearings in San Francisco, California, March 13 and 14, 1972, and St. Louis, Missouri, March 15 and 16, 1972.

The Council received 11,832 comments on 23 issues from 4,782 respondents during the 100-day period of public review, and prepared a 320-page "Summary/Analysis of the Public Response . . ." for distribution to the public and all respondents.

The Council considered all the issues and various alternatives raised by the public and Federal and State agencies and forwarded its recommendations to the President, July 24, 1973. On August 3, 1973, President Nixon wrote Chairman Rogers C. B. Morton approving the new principles and standards for planning water and related land resources, as recommended in Chairman Morton's letter of July 24, 1973.

The Council's "Principles and Standards" will supersede the present criteria, "Policies, Standards and Procedures in the Formulation, Evaluation, and Review of Plans for Use and Development of Water and Related Land Resources" approved by the President May 15, 1962, printed and commonly known as Senate Document No. 97.

What is the major significance of the revised Principles and Standards for planning water and related resources?

They place environmental concerns on a basis equal to economic development. This allows planners to truly recognize the environmental tradeoffs in resource planning.

In addition to considering those objectives, the consideration of adverse and beneficial effects of regional development and social well being recognizes other aspects of water resource planning. The display of four accounts—national economic development, environmental quality, regional development and social well being—gives the Congress and others an opportunity to evaluate fully the projected effects and tradeoffs of alternative plans.

As the Principles and Standards are written now, formulation of alternative plans will be based on national economic development and environmental quality objectives. Basically a recommended plan must have net economic development benefits except where the deficiency in net benefit results from benefits foregone or additional costs incurred to serve the environmental quality objective. In other words, a plan with no net economic benefit could be recommended if it has overriding long-term environmental benefits.

Also there is a provision of the Principles that says a departmental secretary or agency head may make an exception to the net economic benefit rule if he determines that the circumstances unique to the planning and formulation processes warrant an exception. What this means is that under unusual circumstances it is possible to go forward with a plan that does not have net benefits under either of the objectives. Obviously, the economic development and environmental quality objectives make up the significant accounts; however, beneficial and adverse effects on regional development and social well being will be displayed where appropriate to give further assistance to the decision maker.

How do the new requirements address today's needs?

The Principles and Standards, approved by the President, and published in the Federal Register, represent a real effort on the part of water resource officials and agencies to make the planning process relevant to today's situation.

This is in recognition that the values of our country are changing. The people are demanding that environmental considerations be given equal consideration and weighed heavily in the planning process.

This is not to imply that we have failed to give serious consideration to environmental effects in the past. It just means that now we are actually going to be developing alternative plans to give decision makers a choice that can be made with full knowledge of the beneficial and adverse effects as displayed in the accounts.

Although the revisions in the Principles and Standards are highly significant, I do not want to indicate that there has been a radical departure from Senate Document 97. There are many techniques used in the past in evaluating the projects by the water agencies that will be just as appropriate under the new Principles and Standards. As I see it, the most significant changes are the way the effects of the various alternative plans are displayed in the various accounts, and the discount rate. As far as some of the basic planning principles or techniques that go into the planning process itself, most of them have not been changed.

What effect will the new Principles and Standards have on the public's role?

The initial impact insofar as the public is concerned will relate to identifying and specifying the issues to attain the objectives early in the planning processes. The plan formulation requires that public participation be sought early and continually throughout the process. There will be at least two alternative plans formulated;

one a plan that best optimizes contributions to the national economic development objective and one that best serves the environmental objective. Other plans contributing to the objectives will then be formulated to develop the balance of optimum resource use. The public will have a very direct and strong input in selecting that balance.

Under the new Principles and Standards the public can participate on the basis that there are alternatives to react to. Previously, with the national economic development approach, there was just the one type of plan and the reaction was limited to "take it or leave it." With a number of alternatives expressing the concerns of different groups that have special interests as well as the public in general, a greater incentive to participate will be generated. I might just add, though, that in this matter of alternative planning, there could be cases where an agency could come up with just one plan. In other words, where there are no conflicts and the plan is basically for a single purpose, there may be no logical alternative. This would be considered an exception.

In carrying out the Principles and Standards some flexibility is called for on the part of the planners and agencies in working with the public. Critical items in this planning process include that of agencies working with the public in actually screening out alternatives at an early date, and then displaying and arraying the final plan. In this manner the public will certainly have an early voice in the matter of initiating the particular steps that will be taken in coming up with alternative plans.

All principal agencies have been developing guidelines and procedures for public participation. In my estimation, the Corps of Engineers has gone about as far as anybody with its "fish bowl" type of planning. I can perceive that with this new approach to planning there will be refinements in agency efforts to obtain meaningful and significant public participation.

Will there be an attempt to set common values on non-monetary measurements?

The new Principles and Standards provide that measurements will be in quantitative or qualitative terms appropriate to the definition of the component being evaluated. It is not envisioned that we would try to have common value units. There have been, however, various evaluation systems which have been developed and are going through the process of refinement. A great deal of work has been done on methods of documenting non-monetary effects, however, there is not a precise system available at the present time. I can foresee that implementation of these Principles and Standards will stimulate progress towards defining positive ways of identifying effects in a descriptive way.

In the past the decision maker, which has been Congress or the Executive Branch, could determine to support or not support a particular project based on the simplicity of the benefit-cost ratio. Under this new approach a benefit-cost ratio will not be displayed. On the other hand, Congressmen and others will have a full accounting of the effects of a project to assist in their decision making.

SYSTEM OF ACCOUNTS

ACCOUNT	BENEFICIAL EFFECTS	ADVERSE EFFECTS	NET BENEFITS
National Economic Development			
Environmental Quality			
Social Well Being			
Regional Development			
Region 1 Region 2 Rest of Nation			

PLAN EFFECTS N.E.D. OBJECTIVE

BENEFICIAL	ADVERSE	NET
Increased Output	Resources Required	Effects Can Be Netted
Externalities	Externalities	

PLAN EFFECTS E.Q. OBJECTIVES

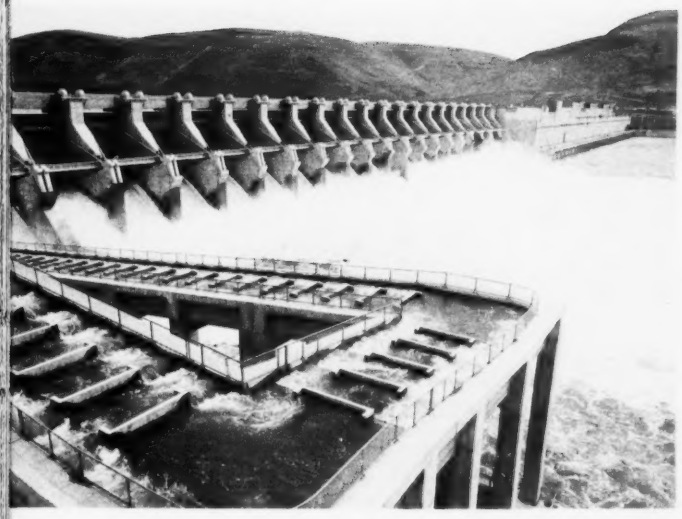
BENEFICIAL	ADVERSE	NET
PROTECT AND IMPROVE NATURAL BEAUTY	DESTROY NATURAL BEAUTY	GENERALLY EFFECTS CAN NOT BE NETTED
PRESERVE NATURAL AND CULTURAL SITES AND ECOLOGICAL SYSTEMS	DESTROY NATURAL AND CULTURAL SITES AND ECOLOGICAL SYSTEMS	
IMPROVE QUALITY OF WATER, LAND AND AIR	REDUCE QUALITY OF WATER, LAND AND AIR	
EROSION CONTROL	INCREASED EROSION	
PRESERVE FREEDOM OF CHOICE CONCERNING IRREVERSIBLE EFFECTS	IRREVERSIBLE COMMITMENT PRECLUDING FUTURE CHOICE OF USE	

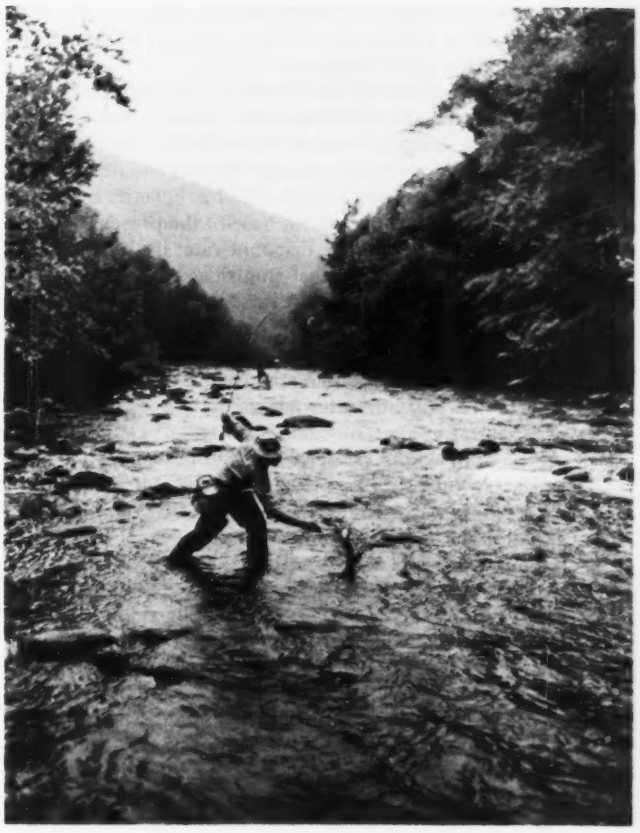
How will agencies apply the "grandfather clause"?

The Principles and Standards say that retroactive applications, the so-called "grandfather clause," will be on a selective basis. This means that each agency will have to look at its backlog of authorized but unfunded projects and select those that will have to be reformulated. Those that are substantially reformulated to meet the Principles and Standards will be submitted to Congress for reauthorization.

The Corps of Engineers, for example, has about 375 projects in the unfunded category which have a total construction cost of over $10 billion.

Details of how this selective basis for authorized but unfunded projects will be applied by the individual agencies are being worked out. We anticipate that difficult





administrative decisions will be encountered. It is conceivable that agencies, with counsel from the Water Resources Council, may determine that it will not be practical at this time to go ahead with some of the authorized and unfunded projects that have been on the shelf for several years. Some of these may be selected for reformulation.

Suppose a special interest group doesn't agree with what is or isn't selected by an agency?

As for an agency having a final decision without recourse to special interests or other groups, numerous recourse possibilities are available to any such action. There is recourse within the Executive Branch in recommending funding of projects, and within the legislative halls of Congress, where they can decide whether or not to go ahead and continue to fund a certain project. And, of course, when people have reason to believe they have been faulted, there is always recourse through the courts.

I might just add this: the decision as to just how these are selected under the retroactive application provision and the way in which they are selected will be of considerable concern to local sponsors, State water interests and also Congressmen. They, of course, may be alarmed if their particular project, which is authorized but not funded, is selected for reformulation while other projects are not.

This emphasizes that there must be a great deal of thought and some very judicious judgment made here as to how the retroactive application is used.

What are your views on the cost sharing issue?

The cost sharing recommendation made in the National Water Commission report has created a heightened interest in the matter of what is an appropriate level of cost sharing in all areas of government—local, State and Federal. We are now working with the various water agencies and it is our plan that sometime this year we will come up with a legislative proposal for recommendation to Congress.

In the final analysis, changes in cost sharing provisions will be done by Congress through legislative action. It would be inappropriate, at this time, to make any comment on cost sharing of any particular function or how it would be applied.

What is the thinking behind switching over to the new discount rate in evaluating water resource projects?

The basic philosophy for the discount rate is that it will be established in accordance with the concept that the Government's investment decisions are related to the cost of borrowing. The rate is based on the average cost of Federal borrowing during the preceding 12 months as determined by the Secretary of the Treasury. For this year it has been established at $6^{7}/_{8}$ percent, which would replace the previously computed rate of $5^{5}/_{8}$ percent for the remainder of this fiscal year. The $5^{5}/_{8}$ percent rate was established under the computation formula used before adoption of the new Principles and Standards. Thus, the new discount rate will have an impact on project formulation. We expect to see different kinds of projects in the future, such as those that are less capital-intensive, and which are geared more to immediate and near-term needs.

The discount rate rationale proposed in the Federal Register in December 1971 was based on the *opportunity cost* concept. The new rate which became effective with

the new Principles and Standards on October 25, 1973, would not be permitted to change more or less than 1/2 of 1 percent in either direction in a year.

In earlier work on the discount rate, a Special Task Force of the Water Resources Council had recommended a concept based on a social rate of time preference. Under that concept the rate would reflect a judgment of society's preferences for benefits and costs in the future as compared to those of the present. In considering the basis for the discount rate, the Council was very concerned that no real empirical method for determining a social discount rate was available. For that reason the Council felt it would be very difficult to obtain general support and understanding for that concept.

One effect an increase in the discount rate is going to have, if there are no other associated factors which will bring about increased benefits, is that the capital cost of projects is going to be more difficult to justify. It will be necessary for the planners to plan projects that have lower capital costs. This may result in a higher operation and maintenance cost. This has a great effect on the way in which projects are formulated. I think this is one of the greatest effects of the increase in a discount rate.

Who will decide which projects are not in line with the new Principles and Standards?

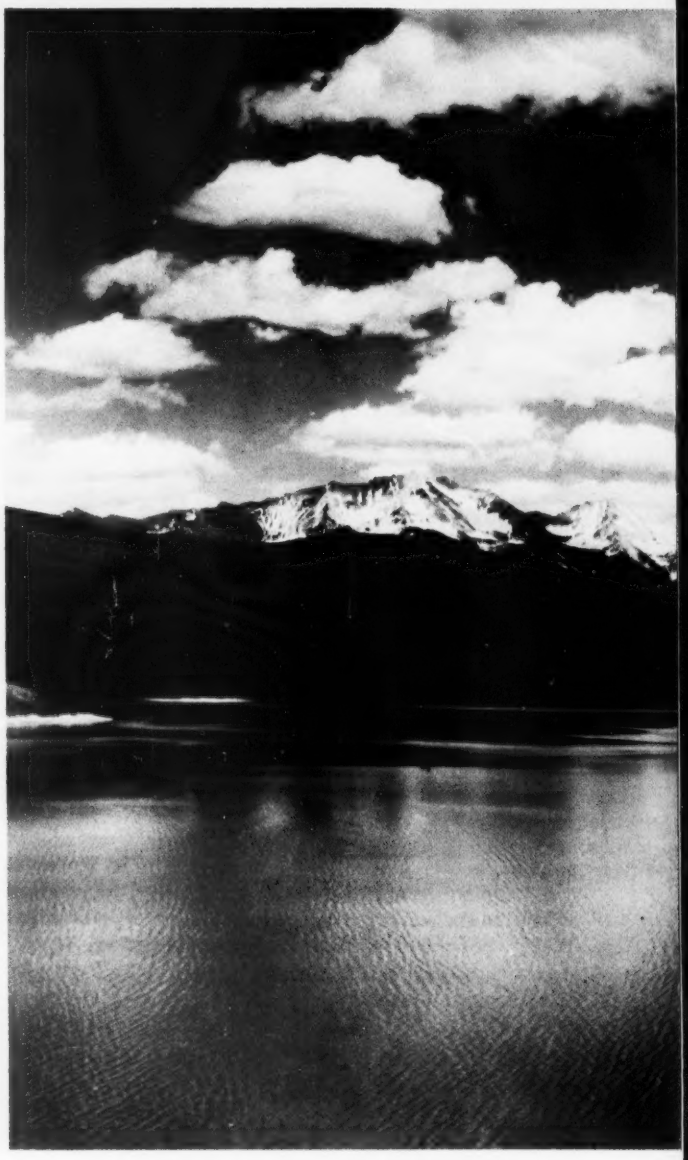
The responsibility for implementing Principles and Standards rests with the individual agencies; and they have the responsibility for developing certain procedures and guidelines. There are new techniques involved, new planning procedures and reformulation that without any doubt will generate some problems. I think one of the immediate questions that these water agencies face concerns projects that they have under investigation. They will need to determine just how much of a reformulation process each investigation will undergo. For some of these it may be necessary for agencies to do very little work in order to have them in line with the Principles and Standards, while others may take a considerable amount of work to actually reformulate and re-evaluate. Considerable judgment will be required by the agencies in making these decisions.

Will the planner's role be more restricted now or will it be strengthened?

Water planning through the years has come a long way. We have at all levels of government highly trained interdisciplinary personnel in the water agencies.

For instance, these planning techniques which have been developed in Principles and Standards are based upon years of activity by the agencies themselves. We have arrived at the point in water planning that we are capable of a more complex evaluation and formulation. However, we must use a great deal of care and judgment to prevent unnecessary detail in planning.

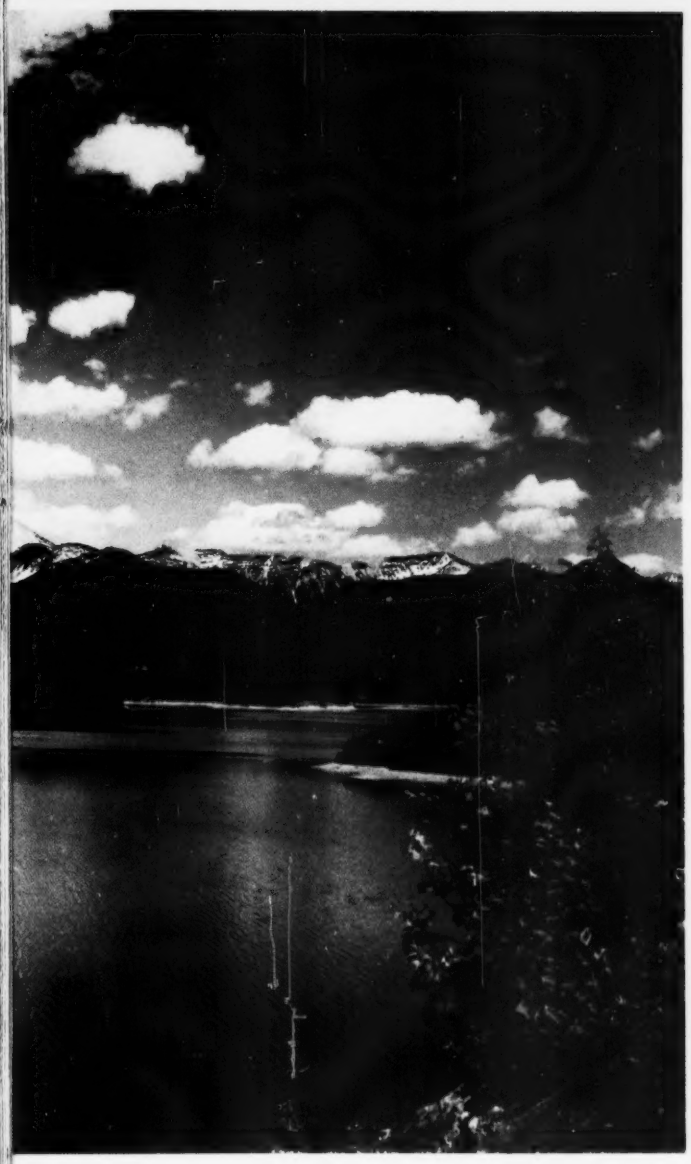
One thing I feel strongly about with this type of planning is that agencies should exercise extreme care and judgment to do only those things necessary to arrive at a desirable level of detail for decision makers to make a logical and appropriate decision. Coupled with this complex planning procedure for Principles and Standards, agencies must do more and more judgmental planning.



What changes do you foresee in the future work of the Council?

Now that the Council has established Principles and Standards under the Water Resources Planning Act, it must turn its attention to their implementation. Each agency is responsible for development of necessary procedures, which are then to be submitted to the Council for review for consistency with the Principles and Standards. That review will represent a substantial new activity for the Council.

The Council will likely develop, with interagency input, certain procedures that would then be utilized by the member agencies. We will have to address ourselves



to improvement in the state-of-the-art planning. We need to review the need for additional data. Research on planning techniques and methodologies to fully implement the Principles and Standards is required. We must make recommendations in the budget process or some other manner to get these activities underway, so that the Principles and Standards can be implemented in those areas where there are weaknesses.

In the evaluation of the environmental quality objective there needs to be a strengthened methodology. We might divide the field of training into two or three layers. The broadest training would deal with overview training or orientation for decision makers. This would be for the agency managers of the various member agency programs. Then it would spread across to more detailed training conducted over an extended period of time, principally by these agencies, but with the assistance of the Council in providing training materials. Also, the Council would perhaps assist by providing personnel to participate in the training programs of the agencies.

How soon do you anticipate changes in either the Principles or Standards?

I would anticipate that the Principles would not change very rapidly, and that they are set for some period of time. The Standards, however, can be modified much easier and as need requires. As we get more experience in the employment of the Standards—without a doubt—we will find it necessary and desirable to make improvements.

How will the Principles and Standards affect non-Federal water resource projects?

Although the Principles and Standards are for Federal agency planning, when Federal agencies have a certain procedure to follow the States often find it convenient to adapt to that procedure in their own planning.

The Principles and Standards would apply not only to Federal participation but to comprehensive planning by the River Basin Commissions and other forms of Federal-State regional institutions.

In the preparation of plans by the River Basin Commissions, where the planning is conducted jointly by the States and the Federal agencies, we expect that the Principles and Standards will provide the basis for that kind of joint planning because they represent the most efficient way to prepare such a plan. In joint planning situations we would expect the States would want to participate on the same basis as the Federal agencies in the planning process.

Do you foresee aggressive implementation of the new Principles and Standards?

For the past several months there has been a sort of hiatus in Federal water planning based on the anticipation of the adoption and approval of the new Principles and Standards by the President. During this period there has been a great deal of uncertainty on the part of the water agencies as to the nature and extent of these Principles and Standards. Agencies have been concerned about the way in which they can follow through on procedures.

Approval of the Principles and Standards by the President has now made it possible for the water agencies and, certainly, the Water Resources Council to move forward aggressively in their implementation. This will result in reformulated plans and will result in some changes in thrust.

We now have concrete guidance within the Executive Branch as to how we should proceed. This I think will have an immediate and positive impact upon the water program because the planners in the agencies can utilize these Principles and Standards with complete knowledge and assurance of recent Presidential approval. I think this is going to be one of the big benefits of getting these Principles and Standards implemented.■

"What is happening today is not merely increased emphasis on environmental factors. It is rather, an evolution of a new way of looking at resources and their use . . ."

THREE-YEAR EVOLUTION

by C. Grant Ash, Ph.D.
Chief, Environmental Resources Branch
Planning Division, Civil Works
Office of the Chief of Engineers

Prepare a full disclosure document taking into account all adverse and beneficial *environmental* impacts relating to any proposed project to assure that such effects receive proper consideration along with *social, economic* and *engineering* aspects in arriving at final decisions in the overall public interest.

That is the objective of the Environmental Impact Statement (EIS).

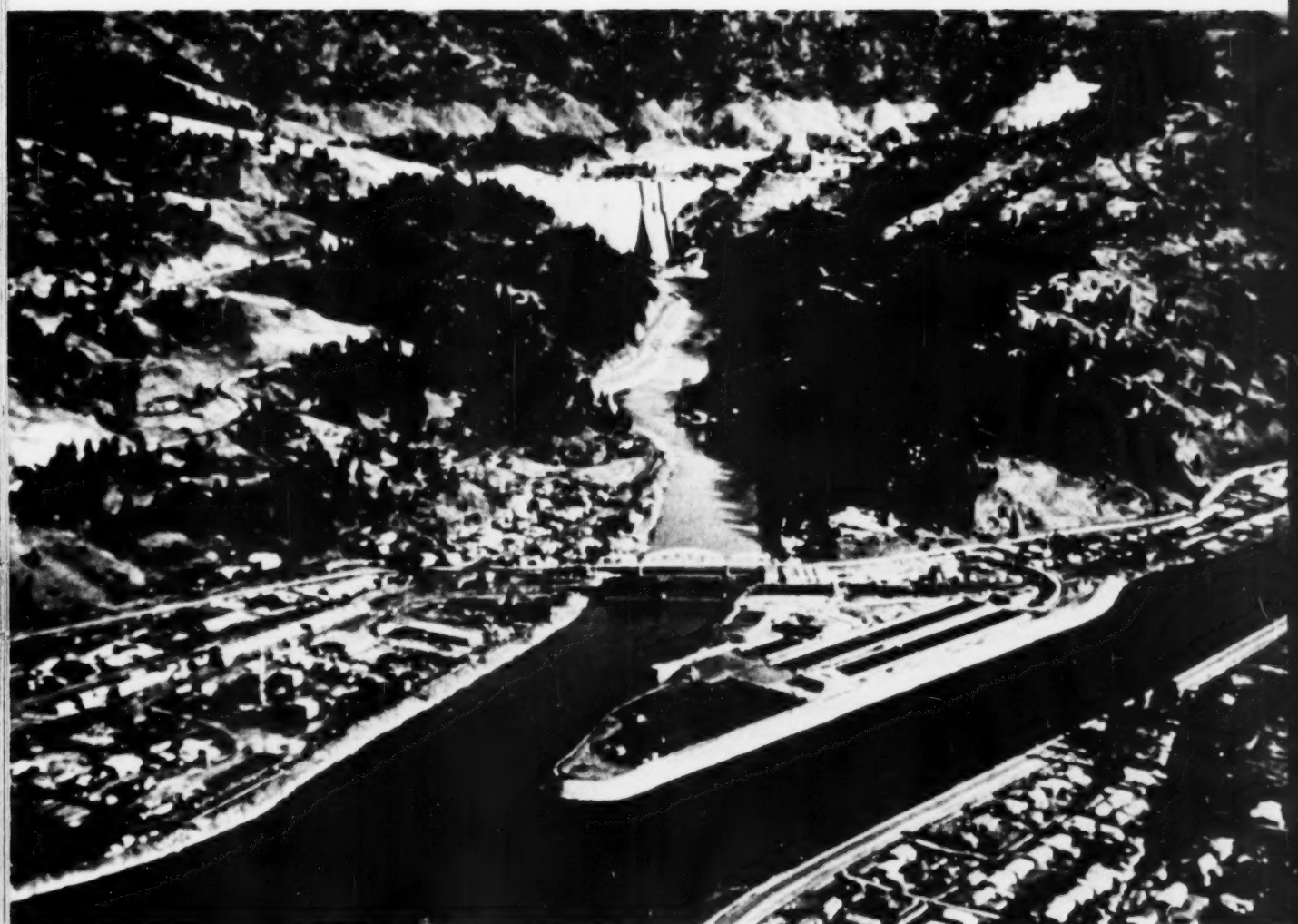
The Army Corps of Engineers has over three years of experience in the preparation of the EIS. To date the Corps has filed over 900 draft and final statements with the Council on Environmental Quality (CEQ). These EIS have been prepared for projects both in the initial pre-authorization stages as well as authorized projects already in the categories of advanced engineering and design, construction, or operation and maintenance—or for issuance of construction permits. These projects cover a gamut of purposes and structures involving navigation, flood protection, hurricane protection, bank erosion and recreation facilities. They involve dredgings and channelizations—cutting and fillings—dams, levees and spillways—diversions, jetties and groins—roads, buildings, campsites, marinas, etc.

After three years and 900 statements, it seems appropriate to step back and review the significant events of the past in regard to EIS preparation in order that we might improve procedures and techniques and better serve the public.

First, let us examine the National Environmental Policy Act of 1969 (NEPA). This act, a new approach to environmental management, includes three central elements: First, a general statement of congressional policy, stating a Federal responsibility "to create and maintain . . . productive harmony (between) man and nature;" second, the establishment of a new procedure by which agencies are required to consider, and make public, their decisions which have significant impacts upon environmental resources; and, finally, the creation of a CEQ in the Executive Office of the President, to provide an ongoing organizational focal point for environmental quality as an issue of public policy.

The requirement for publicly disseminated EIS

An impact statement is a prologue for development or changes expected to occur at various stages of project completion.



describing both the environmental effects of, and alternatives to, actions proposed by the agencies established a new and unique mechanism for the achievement of changes in the planning processes.

The language in NEPA was purposefully written in broad and somewhat general terms. Even today certain sections are still being interpreted and debated in both the courts and in Congress. Its provisions, in the words of its sponsor, Senator Henry M. Jackson, were "action-forcing." To the individual who must prepare a statement, the implementation of NEPA has been and still is a dynamic changing process, fraught in many ways with frustration and uncertainties.

Looking back over the last three years, we think we see three definite phases: (1) a period of interpretation, (2) a procedural or letter of the law phase and (3) an integrated planning or intent of the law phase. In reviewing impact statements prepared by other Federal agencies, we see the same phases or trends in their preparation of EIS.

GUIDELINES FOR ASSESSMENT OF EFFECTS OF CIVIL WORKS PROJECTS
Assemble a profile or inventory
Project for "without project" conditions
Make "with project" projections
Identify significant effects
Describe and display effects
Evaluate effects
Consider project modifications
Seek assessment feedback (public and private)
Select proposed alternative
Prepare "Impact Statement"
Prepare "Statement of Findings"

The first phase, the *period of interpretation* is characterized by a lot of talk and not much action. Typical of this phase are long unproductive debates as to what projects require an EIS in accordance with the act, and the preparation of rather meaningless reports based on hurried searches for library data to be used in making rather cursory analysis of the environment. Typically, the data serve only as descriptive information in the EIS rather than the bases for an assessment of the environmental impacts of the project.

It would be expected that at least some time would be spent debating the issues in order to obtain clarification. This was done, but only for a period of short duration.

In the beginning the Civil Works Directorate of the Corps faced a workload of over 2,000 projects requiring an EIS, not counting the additional requirements under the permit program for which the Corps was then responsible. By the end of the first year the Corps had prepared 105 draft impact statements. That first year was somewhat hectically spent in developing detailed guidance and procedures while either preparing statements for recommended and previously authorized projects involved in actions by Congress or for projects under litigation.

On June 4, 1970, when NEPA was just five months old, the 9th U. S. Circuit Court issued the first injunction against a Corps project, stopping channelization on the Gila River in Arizona. There had been only one EIS prepared up to that time. It was dated March 1970 and was a project to study dredging and water quality problems on the Great Lakes. By January 1971, one year after the passage of NEPA, the West Tennessee Tributaries Channelization project also had been stopped and President Nixon issued the order that stopped the Cross-Florida Barge Canal.

The involvement of the courts in implementation and interpretation of NEPA rather subtly, but definitely, led the Corps into the *procedural phase.* In this phase emphasis is placed on adhering to the *letter of the law.*

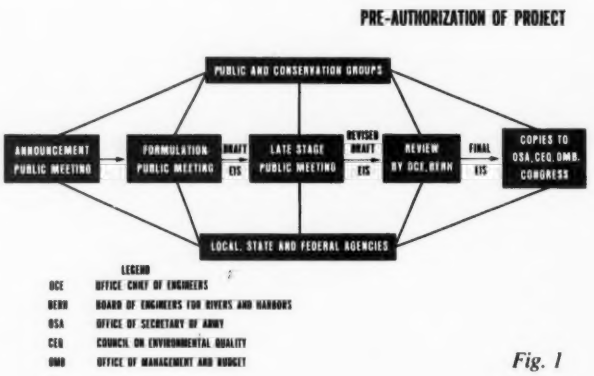

PRE-AUTHORIZATION OF PROJECT
PUBLIC AND CONSERVATION GROUPS
ANNOUNCEMENT PUBLIC MEETING
FORMULATION PUBLIC MEETING
DRAFT EIS
LATE STAGE PUBLIC MEETING
REVISED DRAFT EIS
REVIEW BY OCE, BERH
FINAL EIS
COPIES TO OSA, CEQ, OMB, CONGRESS
LOCAL, STATE AND FEDERAL AGENCIES
LEGEND
OCE OFFICE CHIEF OF ENGINEERS
BERH BOARD OF ENGINEERS FOR RIVERS AND HARBORS
OSA OFFICE OF SECRETARY OF ARMY
CEQ COUNCIL ON ENVIRONMENTAL QUALITY
OMB OFFICE OF MANAGEMENT AND BUDGET

Fig. 1

EIS prepared during this phase can generally be identified by their great bulk and quantity of information. These statements are not necessarily bad. In fact some are very good. They meet every procedural aspect of the law and reveal a tremendous amount of information. A general criticism, however, of EIS prepared by this concept is that the data is hard to relate to impacts and alternatives. The documents are hard to read and many times they are "after action" reports with no clear understanding of how all the facts relate to the decision making process.

We found that such an approach was to a certain extent undermining tried and proven planning procedures. An EIS prepared in accordance with the procedural philosophy, for example, usually contained a little and a lot of all kinds of data—social, economic, environmental—and a little engineering. We found that the EIS document duplicated a great deal of the information

contained in our planning and engineering reports and too often the contents of the different documents were not correlated with each other.

Neither the EIS nor the planning documents provided the decision maker with all the essential facts in a timely manner, and the combined use of the documents was not completely satisfactory. Because of internal pressures, tight schedules and the procedural syndrome, there was a tendency to assign the preparation of the EIS to available staff, some with little training in the environmental area, or to a consulting contractor. This procedure was not bad except for the fact there was also a tendency to separate the group preparing the impact statement from another staff group preparing the project documents. The unsatisfactory results of this procedure became immediately evident to those with review responsibilities. The information presented in the documents differed from each other and varied considerably.

I recall one instance where the environmental setting described in the impact statement was completely different from the Survey Report. Investigation into the cause for such a discrepancy revealed that the young biologist preparing the EIS obtained his descriptive material from the library and had never visited the actual project site.

The key lesson identified during the procedural phase was the neccessity for an interdisciplinary team approach to handle the environmental and social amenities as an integral part of the overall planning process and preparation of the EIS. The EIS must not be made the end in and of itself as the sole purpose of NEPA. Emphasis must be given to those sections and paragraphs in the act which refer to the providing of social and environmental data to the decision maker in a timely manner, so that the facts can be considered to the same depth of understanding and detail as the economic and engineering concepts and information.

The Corps is now well along into the third and, hopefully, last phase in the scheme for preparing EIS. The third phase, which I choose to call the *integrated planning phase,* emphasizes the fulfilling of the real intent of NEPA. Under the integrated planning concept adherence to NEPA for a particular project requires the examination of at least three separate Corps documents—the Survey Report, the EIS, and a Statement of Findings.

For example, if a project were in the pre-authorization stages the principal planning document would be the Survey Report and this report would contain all the pertinent data of a social, economic, environmental and engineering nature. The EIS would be prepared after all the data for the Survey Report had been compiled and would be based on the data and analyses in that report. The EIS is not, however, just a summary document. It reflects the use of the factual information in the Survey Report to answer the specific questions and topics specified by NEPA.

The Statement of Findings is extracted from the Survey Report. This third document is a short, clear statement made by the responsible District Engineer. It summarizes the rationale for his recommendation, which is based on his professional and personal concerns for serving the public's best interests. It also notes his efforts to draw the soundest possible conclusions from data and information in the Survey Report—which would include studies, observations, consultations and any other factors bearing on the action proposed. This Statement of Findings accompanies all final EIS filed with CEQ and is distributed to all parties interested in the Corps activities.

I would like now to describe some of the more significant precepts and approaches to integrated planning and preparation of impact statements, and point out some differences in philosophy and technique. First, please examine the EIS objective stated at the beginning of this article. Early statements prepared shortly after the enactment of NEPA generally fell short of the *full disclosure* concept. They dealt primarily with adverse effects and seldom was reference made to beneficial effects. The environmental aspects of the first statements were based primarily on a review of species of fish and wildlife and a general description of the flora in the area of the project. Seldom was there a reference to ecological systems or impacts on such systems which, in recent instances, has proven more meaningful and effective than individual species analysis. The tendency was to ignore the human environment and there was little data concerning social or economic implications of the action.

The importance of recognizing the significant engineering activities and relating them to environmental impacts at various stages of project completion was only slowly recognized and adopted. Engineering during the earlier periods of EIS preparation was too often interpreted and reflected in the statement as a rather broad overall description of the project without identifying the specific engineering methods and objectives with their impacts. The EIS objective as now stated reflects a shift in emphasis and a closer adherence to the intent of NEPA.

There are 11 steps in the integrated planning process which serve as a guide to the assessment of effects and the preparation of the necessary documents to fulfill the requirements of NEPA for Civil Works projects. Experience has shown that there are no "pat" solutions or schemes which will assure the identification of all impacts or even the significant ones. The identification and analysis of impacts and the development of realistic alternatives is the most difficult part of the planning process. Experience in the Corps shows that while the degree of difficulty is directly related to the complexity and size of the project, the best results are produced when the different tasks are handled in a systematic way.

There are several basic steps common to all systematic planning schemes. These are identified by different titles

Statements are prepared for a gamut of projects including those in the pre-authorization as well as the advanced construction and maintenance stages.

but, nevertheless, accomplish the same objective. The assembling of a profile or inventory of data is such a step and, for our purposes, is the portrayal of existing conditions describing the relevant economic, social, environmental and engineering characteristics in the area affected by the project. The collection of this data must be far more detailed than is essential for mere descriptive purposes. The data should be sufficient to enable planners to perform meaningful analyses of unaltered developments and assess alternate solutions to the local problem. If good judgment is not exercised, however, the inventories can become far more extensive than is necessary for the size and importance of the environmental impact caused by the project. The observation has been made that a fairly successful rule to follow is to conduct the inventories to the same depth of detail that the engineering concepts are portrayed for a particular stage in project development; while recognizing that this rule may have to be adjusted based on the nature of the project.

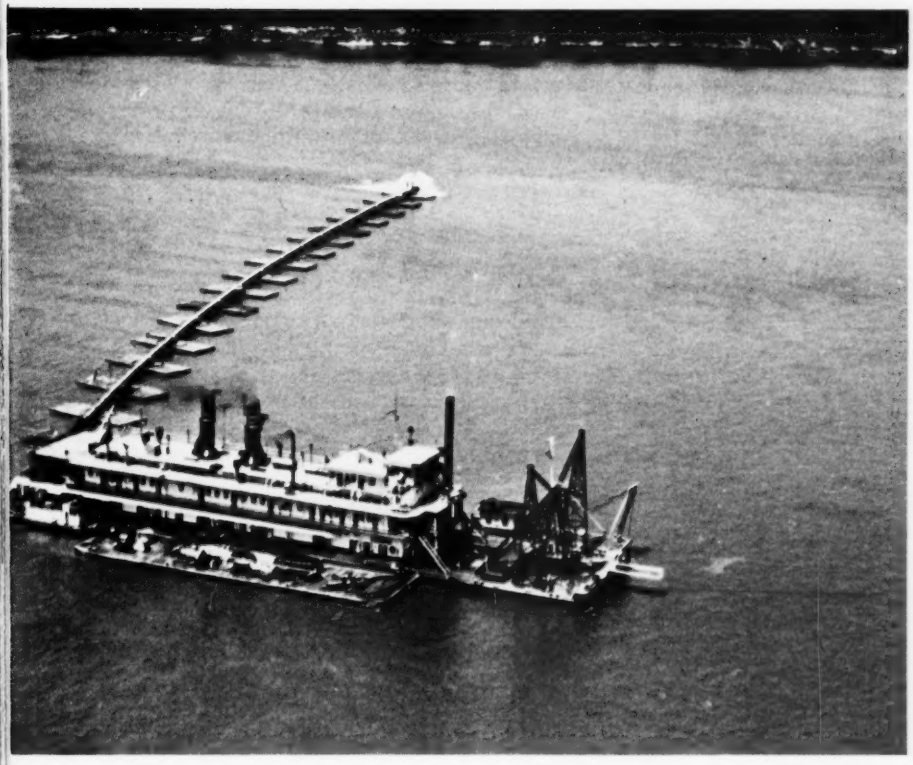
For many years the routine planning process in the Corps of Engineers has included the requirement to project "without project" conditions. These projections cover the expected life of each alternative considered over a reasonable range of probable future conditions. Such projections provide a baseline or control condition for a comparison of the effects of alternative plans. Thus, it was fairly simple to add in social and environmental conditions to the existing planning process to produce an even more complete and clearer "without" picture of the future for a particular proposed project area.

The "with project" plans are developed using the same issues addressed in designing the "without project" projections. At this step in the planning process it is well to remember that the planner will likely be dealing with many alternative solutions to the project problem. Experience suggests that at this stage wise planners deal with the problem in more breadth, covering multiple issues rather than singling out any particular issue for in-depth study. Usually, an interrelationship between economic, social and environmental aspects is found which must be considered regardless of the category in which any given effect is placed.

As stated above, one of the most difficult parts of the process is to identify significant effects. A "significant" effect is defined as one which would be likely to have a material bearing on the decision-making process. Here the approach used is all-important. Experience to date suggests there are no textbook solutions that are completely satisfactory in identifying significant effects. Generally, textbook solutions and data searches by themselves only produce appraisals of environmental worth which are inflated in value compared to the real world. When it comes to impact identification and analysis, there is no substitute for the data produced from well planned field reconnaissances and on-site studies. The out-of-doors is the biologist's laboratory. He does his best work in the field, but he must proceed on the basis of a well thought out and systematic approach. He must not base his findings on a casual trip or two to the project area to "pick the flowers and look at the trees."

Important to the evaluation of effects and assessment of alternatives is the way the information is described and displayed. Adverse and beneficial effects should be identified. For best results the effects of alternative plans should be so displayed as to be easily understood, interpreted, and evaluated—and should show the differences among alternatives.

For example, long lists of floral and faunal species (with their scientific and common names) found in the



One regular use of the environmental statements is to define the impact that dredged material has on various disposal areas.

project area are of little significance to anyone other than perhaps the trained specialist, who may use them to obtain an overall descriptive appreciation for the area. On the other hand, if these species are listed in a table showing seasonal migrations at a given site, existence at alternative sites and some indication of the effect on specific species based on a particular alternative, this kind of display can be very helpful in ultimately reducing the number of alternatives and/or reaching the best solution to the problem.

In the evaluation of effects there is no single method for determining relative values. Public policy, community preferences, and the magnitude and degree of severity of effect are factors to be considered. A number of matrix[1] approaches have been developed and advertised as practical interdisciplinary methods for considering unquantified environmental and social amenities in the evaluation of alternatives for water resource developments. Any of these matrix methods can be an effective tool if properly used in the planning process; but each suffers from certain disadvantages such as: (1) too complex for routine use, (2) difficulty in adopting parameters and weighting factors to local conditions, (3) subjective inputs can control results, and (4) inability to project the public and community policies and preferences.

Matrix analyses are used fairly extensively throughout the Corps, particularly for large complex projects. But the use is limited mostly to the early stages in planning. In a few instances the matrix analyses have been carried through to a point of assigning comparative numerical values to different alternatives. Such figures have assisted the District Engineers in making their decisions, but these figures have not been the only factor which influenced the final recommendation. There is no substitute for trained professional subjective judgments in the evaluation of construction effects on the environment, nor is there likely to be for some time. But matrices analyses should not be precluded from immediate use on a selective basis and work should continue to refine current evaluation systems.

One of the main objectives in identifying adverse effects is to enable the planner to investigate the possibility of eliminating them. In the event this is not feasible, he may wish to mitigate or substitute alternatives for these effects or reduce them to an acceptable level.

The Corps has performed reasonably well in this regard. In a recent assessment of projects in the construction and design stages, it was found that one-third of the 500 projects under construction, or about to be constructed, were modified to accommodate environmental considerations. Similarly, of 200 studies investigated, about one-third of the final alternatives proposed had been significantly changed during the course of the study to minimize the impact on the environment. In 43 percent of the 103 completed projects investigated, the operators had adopted new procedures to help protect the environment.

Experience again shows that a lot of valuable time and effort can be wasted if planners and implementing

engineers fail to seek assessment feedback from the *public.* The *public* is defined as elected officials, government agency representatives (State and Federal), individual citizens, members of conservation groups, members of professional and non-professional societies, etc.

In the course of a pre-authorization survey, three public meetings are held, all of them dedicated to a free exchange of views. Each is preceded by a public notice. At the first such meeting the District Engineer requests public views on the water resource problem that is to be investigated. At the second, some time later, he presents all the alternative solutions that he considers feasible to deal with the problem. At the third he presents the solution that he has tentatively decided to recommend.

For the first two public meetings only analyses of environmental impacts are made. An impact statement as such is not prepared. A lot more detail is given at the second meeting than at the first and the environmental complexity increases as the procedure progresses. At the first meeting little more can be accomplished than to note some of the important environmental resources in the area. At the second meeting environmental information is presented for each alternative solution. At all such meetings the public and conservation groups are contacted—as well as the interested State, local and Federal agencies—in order to solicit comments and effect coordination prior to the meeting.

At least 15 days prior to the Late Stage Public Meeting (Meeting No. 3) the draft EIS is sent to the public and local governmental agencies for their comments. Based on written comments received and the views and opinions expressed at the third public meeting, the District Engineer completes his report and makes his final recommendation on a plan of improvement. Then he prepares a revised draft EIS, writes a Statement of Findings and sends the entire package to his Division Engineer, who reviews it before forwarding on to higher authority.

When the review process has been completed by the Division Engineer, the EIS and report documents are forwarded simultaneously for review to the staffs of the Chief of Engineers and the Board of Engineers for Rivers and Harbors (BERH). Once this review process has been completed, the documents are sent for final comment to interested Federal agencies at the Washington level and to the Governors of the States involved. When all comments have been received and appropriate actions taken, the EIS is finalized. Note the public and agency access to the EIS throughout the planning and review process in figure 1.

The final EIS then goes from the Chief of Engineers, along with his report, to the Secretary of the Army, who first sends it to the Office of Management and Budget (OMB) for review and clearance and then to the Congress. The final EIS is also filed with CEQ.

Once the survey report is completed and submitted to the Congress, the project or projects that it recommends must be authorized for construction, funds must be appropriated, and the Corps must plan the project in full engineering detail—which is the "advance engineering and design" phase. Design memoranda and detailed studies are completed at this time.

If the project is approved and the money appropriated, construction contracts are developed and let, permitting construction to commence. During these latter phases (engineering and design, and construction) the EIS is re-

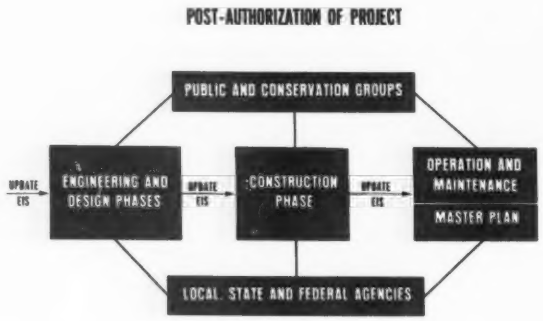


Fig. 2

Tradeoffs for flood control often range from aesthetic to downstream flow effects on the environment, and statements on the impacts increasingly enter into the decision-making process.

Any project that is likely to have an appreciable effect on the environment, such as a dike field that could alter the meandering of a river, is evaluated for various impacts.

viewed every three years to see if it is still appropriate. When necessary it is updated, added to, or rewritten to reflect the current environmental situation. The average total time required from concept to completion of a project is about 14 years. This period allows ample time for essential environmental studies, analyses of impacts, weighing of alternative concepts, and public coordination. Again, the public and agencies have access to the review process during each phase, as shown in figure 2.

In summary, the Environmental Impact Statements prepared by the Corps today are considered to be environmental *full disclosure* statements. They are processed in roughly the same manner as the engineering reports. The environmental-social amenities are made known to the decision maker at the same time and in the same depth of detail as the economic-engineering data. Through the entire process the environmental-social aspects of any forthcoming action are considered not just by the Corps but also by Federal, State and local agencies, the Congress, and the general public, including conservation groups. Environmental-social factors are not treated as mutually exclusive areas of consideration but are incorporated into general approaches that contemplate the engineering, institutional and political implications as well. The Corps, as a public agency, is seeking well thought out, publicly acceptable solutions reflecting the broad overall public interest.

What is happening today is not simply the result of increased emphasis on environmental factors in our planning and management activities. It is rather the evolution of a new way of looking at resources and their use—new concepts of planning. No one, not even those most energetic in bringing these changes to pass, can define all of these new concepts with any precision. It's something we must work out together. So it is up to all of us—we of the government, people outside the government, and all the many disciplines now being harnessed to unfamiliar partners—to help make the necessary adaptations as smoothly and harmoniously and effectively as we can.■

WAVE BREAKING

A SELF-HELP TACTIC

by **Ronald Buddecke** and **Norman Arno**

Great Lakes property owners who once relied on wide stretches of beach to ward off the wind-driven storm waves now desperately depend on Corps of Engineers recommended tactics to break the force of waves lashing at their doors.

Some of the highest lake levels on record have again submerged the natural beaches that normally protect the highly erodible bluffs supporting a mix of summer cottages and permanent homes in lake-shore communities. Their shoreline residents eagerly seek any help they can get and prefer not to ask out loud: "Will it hold up against next year's storms?"

While the flooding that may accompany Great Lakes storms is a matter of Federal concern, the erosion of lake front property is not. Congress has never authorized any Federal agency to assist property owners in combatting erosion in a manner similar to the Corps responsibility for public flood control projects.

However, as purveyors of expertise in matters relating to water resources, the Corps feels an obligation to assist these people as much as it can. This feeling generated a desire to help shoreline residents combat high water induced problems by distributing easy to read instructions coinciding with the prevailing air of do-it-yourself protection against wave destruction.

Mrs. Miriam McLennan, annual summer long resident of the Roosevelt Beach area of Wilson in upper New York State, once owned 90 feet lakeward of her summer home. Today, only 40 feet remain between her cottage and the 28-foot bluff that angles sharply down to Lake Ontario.

A student of geology would quickly note the susceptibility of the soil at the bottom of the bluff to undercutting by repeated wave action, eventually toppling another overhanging section of bluff into the water. Since the spring 1973 lake storm, Mrs. McLennan has contracted for 175 feet of shoreline protection costing her $7500 and consisting of a partial stone revetment. Hopefully, the massive, seven-ton rocks will prevent further undercutting. A gnawing doubt lingers, however, regarding the remaining bluff line she didn't have the money to protect. The forces of erosion may just find it that much easier to "flank" her revetment.

Back in 1936 Mrs. McLennan's father owned an 80 x 110 foot lot on the lakeside of a road that has since disappeared. Her neighbors of many years standing have similar stories to tell.

During the intervening years, the culprit has been the wind driven waves which slam into the shoreline with an intense surge of waterborne energy, undermining the shore's upland.

Millions in private funds are being spent to repair the damage, to construct new shoreline construction, or to relocate homes farther back from the destructive storm waves. Inadequate planning and design, however, can defeat these home protection projects.

Thus, the Corps can do no more than cooperate with the Great Lakes States in providing technical assistance in what amounts to a "self-help" program. This informal self-help program is being pursued in two ways. One is a simple-to-follow brochure, the other is a technical counseling effort.

The *Help Yourself* brochure graphically depicts eight typical problem conditions. Once the lakeshore property owner identifies the one closest to his or her own situa-

Great Lakes property owners facing destruction of their shoreline homes from erosion are receiving technical assistance through such aids as this self-help oriented brochure.

Right-An "orange peel" hoists a giant rock prior to swinging it into place on a stone "toe" sloping offshore from this concrete groin.

Mr. Buddecke is a planner in the Special Studies Branch, Planning Division and Mr. Arno is Assistant Chief, Engineering Division, North Central Division, Corps of Engineers.

tion, the owner matches that number with the possible solutions to prevention of further erosion. Each possible solution is also illustrated by a sketch right on the brochure, so the property owner will comprehend exactly how a proper seawall, revetment or groin looks.

The brochure also provides construction guidelines the property owner can use in talking with a contractor. Many of the latter have their own concepts of what constitutes proper erosion protection. In some instances, contractor recommended fixes have proved less effective than home remedies. For example, one contractor touted the use of junked car bodies for slope protection. Yet the low-density vehicle frames were no match for the tremendous fury of storm-driven waves that quickly scattered them along the lake bottom like sands of grain in the tide.

A dike composed of rock and water filled barrels backed by plywood sheeting, which was in turn buttressed by hundreds of sandbags, failed in the next storm. While such measures may contain slowly rising flood waters, they were ineffective against crashing waves that scoured out the ground under the barrels and then scattered them with wave action.

Even concrete seawalls without proper footing or toe protection were toppled by the wave scouring action. Vern Goodwin of Irondequoit, a suburb of Rochester, lost his breakwall and the 15 feet of beach in front of it. The high waters of Lake Ontario now lap at his homemade crib that stands between his house and the lake. His crib is built of iron gratings containing loose stone, cinder block, barrels of rock and sandbags. Evident up and down Goodwin's street are the ubiquitous sandbags provided by the Corps to contain the flooding of lake front properties during the spring 1973 storms.

While not as professional looking as the shore protection constructions put together by contractors, Mr. Goodwin's crib utilizes the basic principles contained in the Corps brochure and has successfully held against 1973's onslaught of pounding waves.

Anticipating the next series of storms, representatives of the Corps' North Central Division, its four Great Lakes districts and Coastal Engineering Research Center visited the multistate shorefront communities to answer questions from concerned citizens.

Selecting centralized locations several hundred miles apart, Corps representatives repeatedly joined with State officials to hold public meetings for the benefit of each area's shorefront property owners. It was at these meetings that many citizens realized for the first time that both Corps and/or State permits were required before shoreline construction could begin legally. The Corps, historically, has always been responsible for permits on construction in navigable waters under Section 10 of the River and Harbor Act of March 1899.

The States, however, were discovered to have differing sets of requirements based on their own unique historical precedents. Thus, one public meeting attendee wondered out loud why his own State would continue to tax the

A representative from the Buffalo District points out proper use of the Corps' self-help brochure at an erosion workshop.

portions of shore front property that no longer exist as dry land.

A vital point made by Corps personnel at these meetings was the necessity of neighborhood cooperation. For if one's neighbor doesn't construct any shore protection, the private property owner's shorefront bulkhead, seawall or revetment would eventually be flanked at one or both ends of his lakeside property line unless he provided his own flanking by tying his construction directly into the bluff behind.

This advice has been readily accepted where permanent residents live side by side. Harry Bolton, president of the Greece (N.Y.) High Water Task Force, invited Corps representatives to inspect his neighborhood's response. Using 10-foot long vertical pieces of iron pipe bolted to horizontally placed angle iron, with the help of neighbors he constructed his own heavy gauge wire mesh crib. The crib was then filled with gravel and cinder block up to the level of his own backyard.

His neighbors on both sides had constructed similar cribs, so that no gaps now exist along that stretch of Edgemere Drive shared by these organized residents. With confidence born of taking their own positive steps to protect their own, Bolton and his neighbors anticipate capping these rock-filled cribs with concrete that will both reinforce their structures and recreate the aesthetic appearance that existed prior to the storm damage.

Along a less densely populated semi-rural area of lake front, Floyd Eddy and his two neighbors pooled their available funds and contracted for a six-foot high seawall of concrete to replace the gravel crib washed out

The "culprit" is this wind-whipped wave moving against an unprotected shoreline.

by the last storm. The wall is anchored into the bedrock by means of 3/4-inch steel rods and backfilled with gravel between supporting wing walls. A topsoil fill on top of the gravel will be seeded in order to create a pleasant backyard lawn sloping down to the water's edge.

The foreman for the concrete construction company doing Mr. Eddy's job offered the information that his outfit was "booked up till next spring" building the same kind of shore protection for other property owners along the lake. The same is true of most Great Lakes contractors building these shore protection devices. However, the adequacy of these contractor built structures varies from very good to very bad.

Major General E. Graves,
U.S. Army Engineering Division,
North Central,
536 South Clark Street,
Chicago, Illinois,
U.S.A. 60605

Dear General Graves:

Re: Great Lakes Shoreline
Problems and Solutions

I have recently had the opportunity of reviewing the publication put out by your Division on the problems of shore erosion and protection in the Great Lakes . The Department of Public Works has been labouring to produce a pamphlet covering much the same subject. The treatment given in your pamphlet is ideal for our purposes and I would like to receive your permission to use the same material in a similar layout with minor modifications to suit Canadian conditions.

Appropriate recognition would be made of the source and the excellent work done by the U.S. Corps of Engineers.

Yours sincerely,

C. K. Hurst, P. Eng.,
Chief Engineer.

This letter indicates the international nature of the Great Lakes erosion problem. The reply from General Graves invited Canadian participation in planning a revision of the brochure.

Most shoreline residents try to refrain from taking pessimistic viewpoints toward their situations, realizing that do-nothing attitudes would only lose them even more of their own property. However, the gnawing question was repeatedly raised at each public session that somehow the lake levels could be dropped by increasing the flow into the St. Lawrence River during high water periods. At such times Corps personnel can only point out that this is a subject whose primary jurisdiction belongs to the International Joint Commission. The Commission was organized in 1910 by Canada and the U.S. to oversee just such common concerns.

The Corps representatives can, however, explain the Great Lakes conditions that create the critical situation faced by shoreline property owners. All five lakes and their tributaries must eventually funnel through the St. Lawrence River at the eastern end of Lake Ontario and into the Atlantic Ocean. However, the Great Lakes —with their connecting rivers and Lake St. Clair above Detroit—have a total water surface of about 95,000 square miles. The International Boundary passes through Lakes Superior, Huron, Erie and Ontario. Only Lake Michigan is entirely within the U.S.

In concert the Great Lakes act as a system of reservoirs, except for the fact that their size makes them unique. As giant reservoirs they respond to changes in the amount of precipitation and ground runoff received each year. The lake levels are again approaching record highs (established in 1952) because the precipitation of recent years over the entire Great Lakes Basin has exceeded the basin averages. The reverse was true in the years leading to the 1964-65 crisis during which extremely low lake levels created navigation and recreation problems.

A property owner stands on the bluff overlooking her latest shore protection works—a partial stone revetment—and hopes further loss of her land will end.

Several neighbors share this newly poured concrete seawall in an attempt to prevent flanking. The 6-foot wall is being backfilled with gravel by a contractor's crane.

Despite the tendency to affix patterns to everything in nature, a century of record keeping in the basin indicates *no predictable cycles of long-term high and low water. Both the intervals and time spans of each high and low period have varied widely and erratically.*

The records merely show that the ranges between extreme monthly highs to extreme monthly lows have varied from 3.8 feet on Lake Superior to as much as 6.6 feet on Lake Ontario. Obviously, Lake Ontario is subject to the greatest range in level changes because it also feels the effects of the fluctuations from the other four upstream lakes.

Seasonal fluctuations, on the other hand, reflect only the annual hydrologic cycle, characterized by higher water supplies during the spring and early summer. The magnitudes of seasonal fluctuations are quite small. They average about 1 foot on Lakes Superior, Michigan and Huron, 1.5 feet on Lake Erie and 1.8 feet on Lake Ontario. Again, Lake Ontario has the largest fluctuation, since it is the lowest in the chain.

Short-period fluctuations, however, last from only a few hours to several days at most and are caused by meteorological disturbances, such as the severe spring 1973 storms that bit off huge chunks of coastal property. The effect of high water levels in themselves would not contribute to property damage were it not for the winds that whip these large bodies of water into waves several feet high.

In many areas on the lakes, depending on the wind direction, either those shorefront properties with a northeast or northwest exposure will be the hardest hit by a given storm, each one gaining power as it moves eastward or westward along the flat lake surfaces until it finally strikes shore.

The wind also combines with differences in barometric pressure to tilt a lake surface upward in the direction of the prevailing wind. This phenomenon creates temporary imbalances in the water levels at various lake locations, making an excess of water available for wave action to push onshore at certain locations.

Since so many people live right on the shoreline, and commercial interests depend on the lake waters for navigation, hydroelectric and thermal power, recreation and domestic water supply, the amount of erodible shoreline is significant to the Great Lakes economy. According to the National Shoreline study made by the Corps, some 214 out of the 1000 miles of developed shoreline were found to be of a geological condition susceptible to severe or critical erosion.

Critical erosion is defined by the Corps as "shorelands where erosion presents a serious problem because the rate of erosion, considered in conjunction with economic, industrial, recreational, agricultural, navigational, demographic, ecological, and other relevant factors, indicates that action to halt such erosion may be economically justified."

Corps teams of erosion specialists try to stress this concept at each of the State sponsored *erosion control workshops* that were conducted for the public at 15 different locations along the five-lake shoreline.

Aimed at both contractors and homeowners, each workshop followed a typical five-part format. Usually a representative of that State's Department of Natural Resources introduced the panel members and summarized the problems. Then Corps personnel from the nearest district office described the *Help Yourself* brochure in detail with the aid of slides. A Soil Conservation Service representative, when available, discussed various bank stabilization measures. Finally, both Corps and local State officials explained their respective permit application processes.

After a break, the entire team sat down on stage as a panel of experts to answer specific questions.

In terms of problem solving, this type of technical assistance program is inadequate. The cost of permanent shore protection is clearly beyond the financial capabilities of most private shore property owners. Those most helped suffered flood damage and were thus able to make small Business Administration disaster loans to assist them in contracting for or building their own shore protection structures.

Those who used their own home remedies generally paid out less money but, knowingly or unknowingly, took greater risks. They usually saw their inadequate structures ripped apart by storm wave action, received no return on their investment and lost even more of their property to the lakes. Some of the grossest violations of shore protection construction are included in the *Help Yourself* brochure to show property owners what not to do.

Thus far, no permanent decision has been reached on which way to go. Currently, there are no Federal laws permitting Federal assistance to private property owners suffering shore erosion damages. There are however, many worthwhile programs using existing authority that can be identified and justified.

One example is the building of demonstration projects to develop and test low-cost methods of shore protection in an effort to improve planning and design—such as those planned by the State of Michigan. Fourteen projects are being built by Michigan at a cost of $400,000 to test innovative shore protection designs.

Governments can participate in developing public works while monitoring private shore protection measures, and evaluate both for their effectiveness. Both successes and failures could be recorded. Currently available research funds could be used to carry on the program and prepare the documentation reports.

Another large program could involve shoreland management measures. These would include studies into the use of zoning, structural setbacks, acquisition and relocation as methods of reducing future erosion and flooding damages on the Great Lakes. The value of such a program lies in the fact that about 1600 miles, or 60 percent, of the Great Lakes shorelands susceptible to erosion are still undeveloped and can, therefore, still be saved from misuse. Establishing proper land use controls at this time would prevent millions of dollars in future losses.

Remnants of concrete steps leading down to a submerged beach are being replaced by a "new look" of homemade cribs and bulkheads.

Since pressure for shoreland utilization will be extremely intense in the next few years, time is a most important factor. Regulatory controls must not only be established quickly, but must also be based on sound engineering and scientific data in order to be legally defensible. The general public and local officials must be thoroughly educated to the necessity for such controls and the procedures for implementation.

As one local newspaperman admitted, off the record, a lot of his friends build on impossible shoreline sites to start with and should expect what they get from Mother Nature. Therefore, the problem in the coastal zone is not so much in defining what needs to be done, but rather the commitment to the task of doing it.

The Great Lakes Region is paying the price for inadequate shoreland programs. Some advocate passing on this cost to the Nation in the future. It all depends on how we, as a Nation, decide to approach what is basically a regional problem. This particular region is located within the highly industrialized North Central area. Although it covers but four percent of our land area, this region contains 14.4 percent of the population and produces 50 percent of the Nation's steel. Within the Great Lakes Region are land and water areas belonging to 193 counties in eight States.

While those responsible for deciding issues of national scope deliberate, Great Lakes communities continue to demand more copies of the Corps brochure. Inadequate as it may seem against the awesome power of the lakes, the Corps' small investment in the brochure and erosion control workshops represents a fighting chance for shoreline property owners. Both fill the activity and information vacuum that previously existed, and serve as temporary measures to combat immediate problems.

These stopgap measures are meant only as a holding action while a longterm strategy is being laid out for reducing Great Lakes shoreland damage. No single alternative will reduce erosion losses. A combination of all available alternatives however, can provide a potential for reducing these damages over a span of time.

To develop and implement such a strategy will depend on greater knowledge, better communications, closer cooperation and more legal authority than currently exists. There will also need to be an increasing commitment of resources toward reducing shoreland damage.

The North Central Division of the Corps, working with the Federal Regional Council, the Great Lakes Basin Commission and the Great Lakes States, are moving toward development of a strategy that can be supported by all levels of government. The strategy being formulated will emphasize the importance of reducing future shore damage through land management concepts. A cornerstone of this strategy is the development of technical data on which to base zoning concepts. The future of our shoreline resources will depend on the success of that strategy.■

Events, Deeds & Deliberations

Mattress Money

Rising costs are catching up with one of the Corps most time-honored but unusual projects—laying concrete "mattress" revetments along the lower Mississippi River each summer.

Each "mattress" is composed of 20 concrete blocks strung together and reinforced by stainless steel wire that provides both flexibility and strength. The annual cost of this wire is now between $4 and $6 million, leading the Corps' Construction Engineering Research Laboratory at Champaign, Ill., to look for a less expensive approach at the request of the Mississippi River Commission. The two most feasible solutions are to substitute a less expensive corrosion-resistant metal or reduce the quantity in these "mattresses," which are used to stabilize eroding banks and maintain navigation channels.

Declaration of Others

Everyone remembers Tropical Storm Agnes and its June 1972 swath of destruction. The widespread flooding of the Mississippi Valley in the spring of 1973 set new records for high water in some areas. That people affected by both disasters received vast amounts of assistance from the Federal government is well known.

On a level of lesser awareness for the general public, however, are the "others" that qualified for Federal flood fighting assistance in the same years. Besides much publicized Agnes, a record 47 "other" officially declared flood related disasters occurred in 1972. By October 1973 the Mississippi flood was already only one of over 40 disaster declarations by the President.

While the scale of damages inflicted and human suffering recorded in the smaller ones never rival the scale of the great disasters, the smaller ones are just as hard on those affected and require identical action by the President to make those areas just as eligible for assistance. For the specific Corps district office and others involved, the 24-hour emergency effort required is just as real.

Change of Heart

An act amending the Land and Water Conservation Fund Act of 1965, relating to the collection of fees in connection with the use of Federal areas for outdoor recreation purposes, was passed on August 1, 1973.

The new act provides that there could be no fees collected for day use and no fees for use of campgrounds at Corps of Engineers projects unless those campgrounds are highly developed and have facilities such as: flush restrooms, showers, visitor protection, tent or trailer spaces, scenic drives, picnic tables, refuse containers and potable water.

The reason for the new act was that the Corps and other Federal agencies were interpreting last year's user fee legislation as directing them to charge fees for day use and for use of campgrounds which were not highly developed.

WRC Registers Meetings

The U.S. Water Resources Council has established a *Meetings Register* to provide information on major meetings in the water and related land resources field.

A telephone number has been provided by the Council (202-254-6394) from 8:30 a.m. to 4:00 p.m. weekdays, so that interested parties may call either to obtain meetings schedules or to add meetings to the Register.

The *Register* has been established to provide wider dissemination of meeting information and to provide a vehicle which could, if used properly, avoid duplication and schedule conflicts. The format of the Register is simple. Each listing is by date, and contains as much of the following information as possible: date of the meeting, name of the sponsoring organization, contact person, subject of the meeting, meeting place, city and State.

No Power Shortage

In the first five months of 1973, 30 inches of rain fell on the Corps Tulsa District where the normal precipitation for the entire year is about 37 inches.

The flood waters were passed downstream through the turbines of the District's seven power-producing projects. Power generated in January 1973 was 21 percent over the same period in 1972. February 1973 rose 163 percent, with March climbing to 394 percent, April to 529 percent and May to 294 percent.

On April 24, 1973, enough water flowed through the gates at Robert S. Kerr Lock and Dam (230,000 cubic feet per second) to supply Oklahoma City for more than 10 years.

New Repository for Off-Shore Samples

The Army Corps of Engineers has obtained a new central location at the University of Texas, Arlington, (UTA) for 25 tons of the world's most extensive ocean floor samples.

The cores were obtained under the Corps' continuing nine year Inner Continental Shelf Sediment and Structure (ICONS) Program. Previously the Corps had its samples stored at the Smithsonian Institute and its own Coastal Engineering Research Center.

The ICONS Program, which began in 1964, involves obtaining ocean floor samples and seismic profiles from the Inner Continental Shelf surrounding the U.S. coast and from the off-shore areas of the Great Lakes.

The cores were taken from the ocean floor at water depths of 15 to 150 feet. They contain a cross-section of marine evolution and sediment transport history useful in studies of beach erosion and beach replenishment.

At the new UTA location, the samples will become more accessible for data extractions by scientific, engineering and government agencies.

SUBSCRIPTION ORDER FORM

ENTER MY SUBSCRIPTION TO *Water Spectrum* (WASP)

☐ $4.50 for one year; ☐ $9.00 for two years; ☐ $13.50 for three years.
Add $1.25 per year for foreign mailing.

(No additional postage is required for mailing within the United States, its possessions, Canada, Mexico, and all Central and South American Countries except Argentina, Brazil, British Honduras, French Guiana, Guyana, and Surinam. For shipment to all other foreign countries include additional postage as quoted.)

Send Subscription to: **Please Print**

NAME—FIRST, LAST

ORGANIZATION OR ADDITIONAL ADDRESS LINE

STREET ADDRESS

CITY STATE ZIP CODE

☐ Remittance Enclosed (Make checks payable to Superintendent of Documents)

☐ Charge to my Deposit Account No .....

MAIL ORDER FORM TO:
Superintendent of Documents,
Government Printing Office,
Washington, D.C. 20402

DEPARTMENT OF THE ARMY
OFFICE OF THE CHIEF OF ENGINEERS
WASHINGTON, D.C. 20314

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE $300

DAEN-CWA-LM

WASP XEROX300XB R 1
XEROX UNIV MICROFILMS
SERIALS DEPT
300 N ZEEB RD
ANN ARBOR MI 48106

POSTAGE AND FEES PAID
DEPARTMENT OF THE ARMY
DoD-314

THIRD CLASS BULK RATE

Impact projections for marinas and other water developments undergo three-year evolution. *See page 28.*